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INTERIM REPORT
March 18, 1993

FOR
BIOVENTING FIELD INITIATIVE
AT
ROBINS AIR FORCE BASE, GEORGIA

to

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INTERIM REPORT
FOR
BIOVENTING FIELD INITIATIVE
AT
ROBINS AIR FORCE BASE, GEORGIA

1.0 INTRODUCTION

This report describes the activities conducted at three sites at Robins Air Force Base (AFB), Georgia, as part of the Bioventing Field Initiative for the U.S. Air Force Center for Environmental Excellence (AFCEE) and the for Environmental Quality Directorate of the Air Force Armstrong Laboratory. This report summarizes the results from the first phase of the study, which includes a soil gas survey, an air permeability test, an in situ respiration test, and installation of a bioventing system. The specific objectives of this task are described in the following section. The test sites at the base are discussed individually, followed by a description of site activities at the background area.

1.1 Objectives

The purpose of these field test methods is to measure the soil gas permeability and microbial activity at three contaminated sites and to evaluate the potential application of the bioventing technology to remediate the sites. The specific test objectives are stated below.

- A small-scale soil gas survey will be conducted to identify an appropriate location for installation of the bioventing system at each site. Soil gas from the candidate sites should exhibit relatively high total petroleum hydrocarbon (TPH) concentrations, relatively low oxygen concentrations, and relatively high carbon dioxide concentrations. An uncontaminated background location will also be identified.
- The soil gas permeability of the soil and the air vent (well) radius of influence will be determined for each site. This will require air to be withdrawn or injected for approximately 8 hours at vent wells located in contaminated soils. Pressure changes will be monitored in an array of monitoring points.

- Immediately following the soil gas permeability test, an in situ respiration test will be conducted at each site. Air will be injected into selected monitoring points to aerate the soils. The in situ oxygen utilization and carbon dioxide production rates will be measured.
- Using the data from the soil gas permeability and in situ respiration tests, an air injection/withdrawal rate will be determined for use in the bioventing test at each site. A blower will be selected, installed, and operated for 6 to 12 months, and periodic measurements of the soil gas composition will be made to evaluate the long-term effectiveness of bioventing.

1.2 Site Description

Robins AFB is located approximately 10 miles south of Macon, Georgia, adjacent to the town of Warner Robins, Georgia. A schematic diagram of the base is shown in Figure 1. The dashed line on the map represents the direction from the main gate to each test site where Site R1 is Site UST 173, Site R2 is Site SS-10, and Site R3 is Site 272. Summaries of the descriptions of each site are presented in the following sections. A detailed description is provided in the Test Plan in Appendix A.

1.2.1 Site 272

A schematic diagram of Site 272 is shown in Figure 2. Site 272 consisted of a 250-gallon diesel tank abandoned in place approximately 10 years ago. The tank was removed in October 1990. Soil sampling performed after tank removal indicated TPH concentrations in excess of 2,000 ppm in some locations. Soil boring logs were not available for the site, but based on observations during tank removal, the site geology is probably similar to that of Site UST 173 (Section 1.2.2). No monitoring wells were present at this site; however, based upon general knowledge of groundwater it was estimated that the depth to water was approximately 30 feet.

1.2.2 Site UST 173

A schematic diagram of Site UST 173 is shown in Figure 3. Site UST 173 had a 1,500-gallon diesel tank next to Building 173 on the base that was abandoned in place approximately 20 years ago. The tank was removed in October 1989. Site investigation activities conducted subsequent

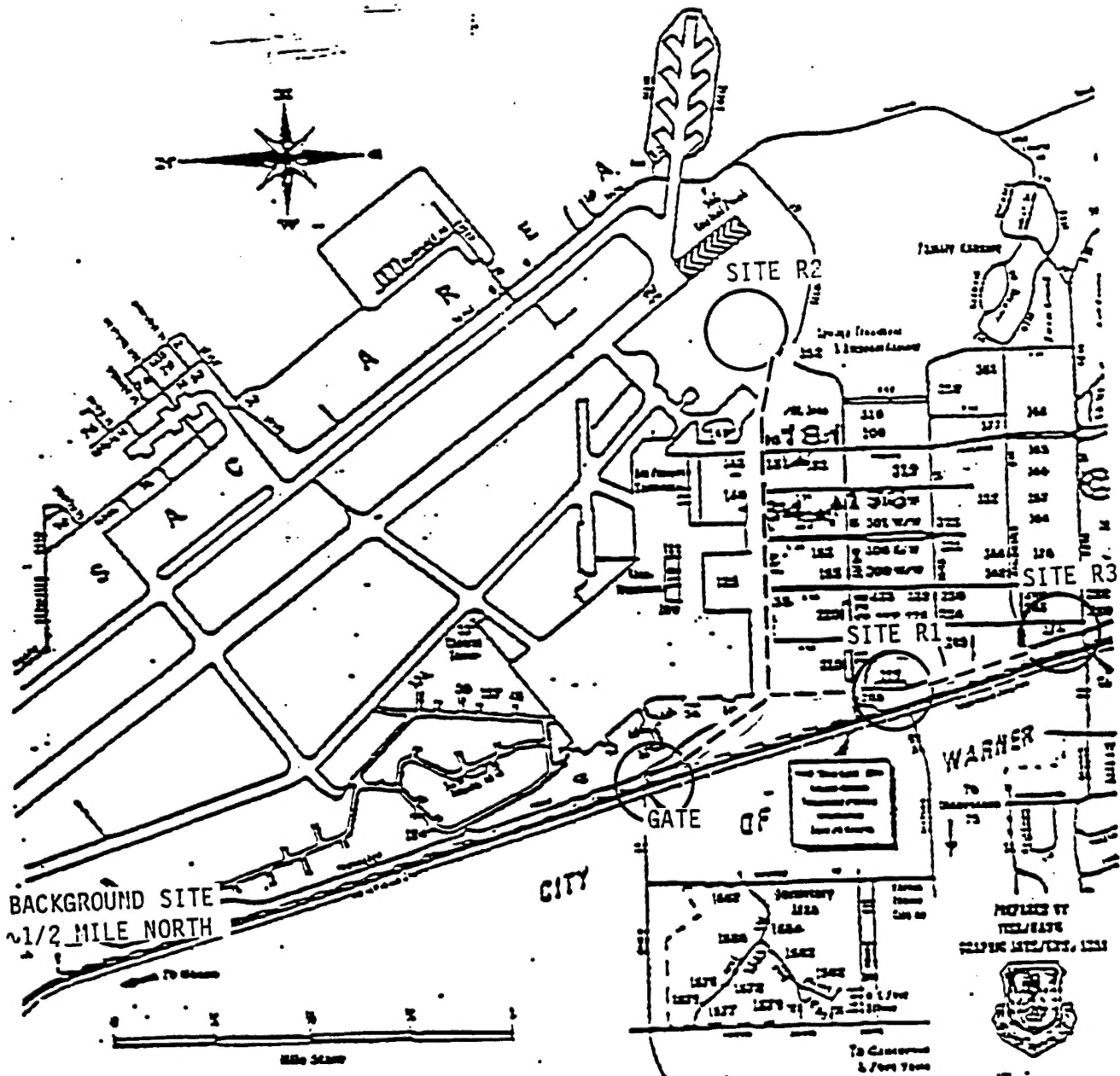


Figure 1. Schematic Diagram of Robins AFB

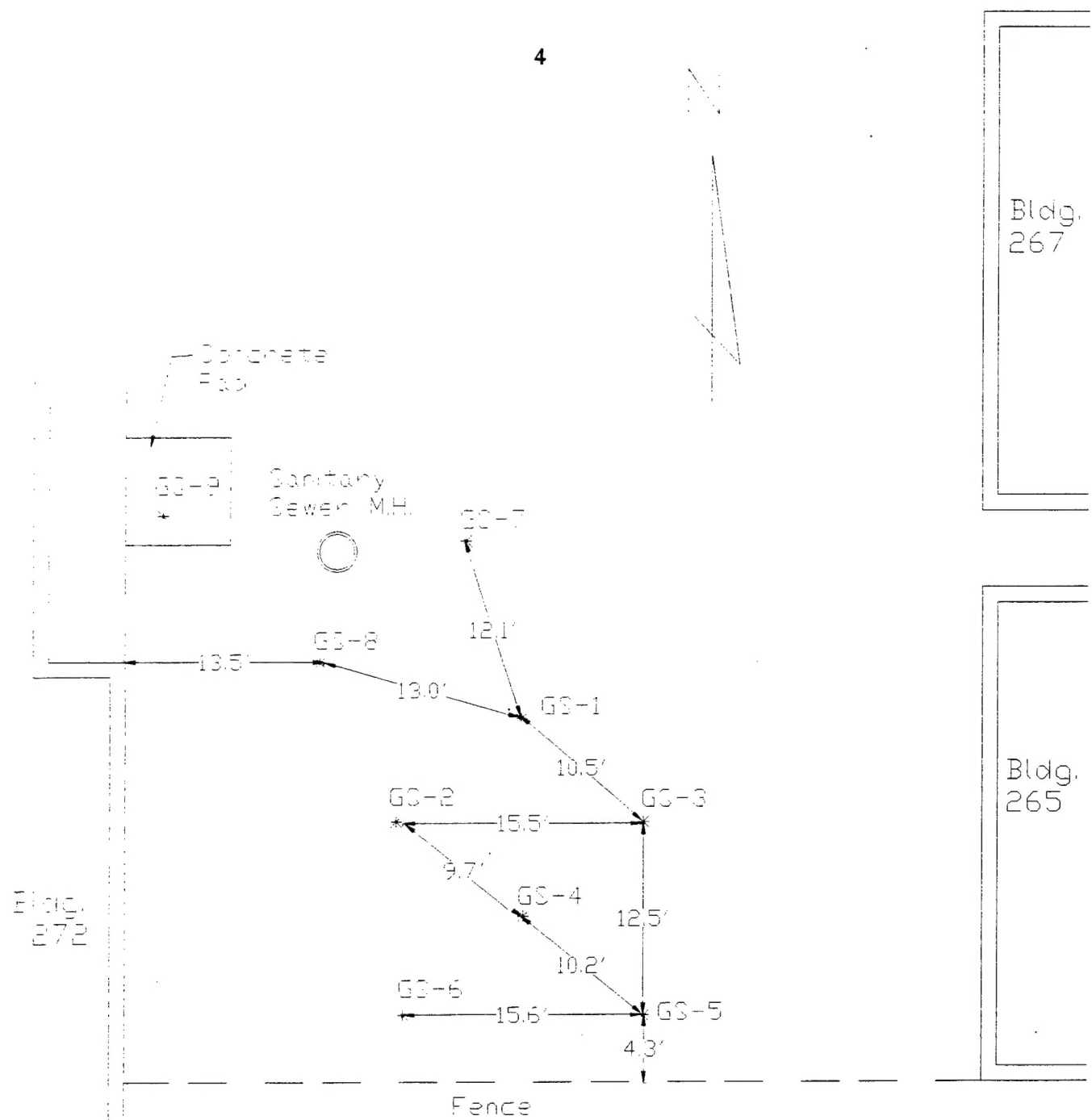


Figure 2. Schematic Diagram of Site 272 at Robins AFB (GS - Soil Gas Survey Point)

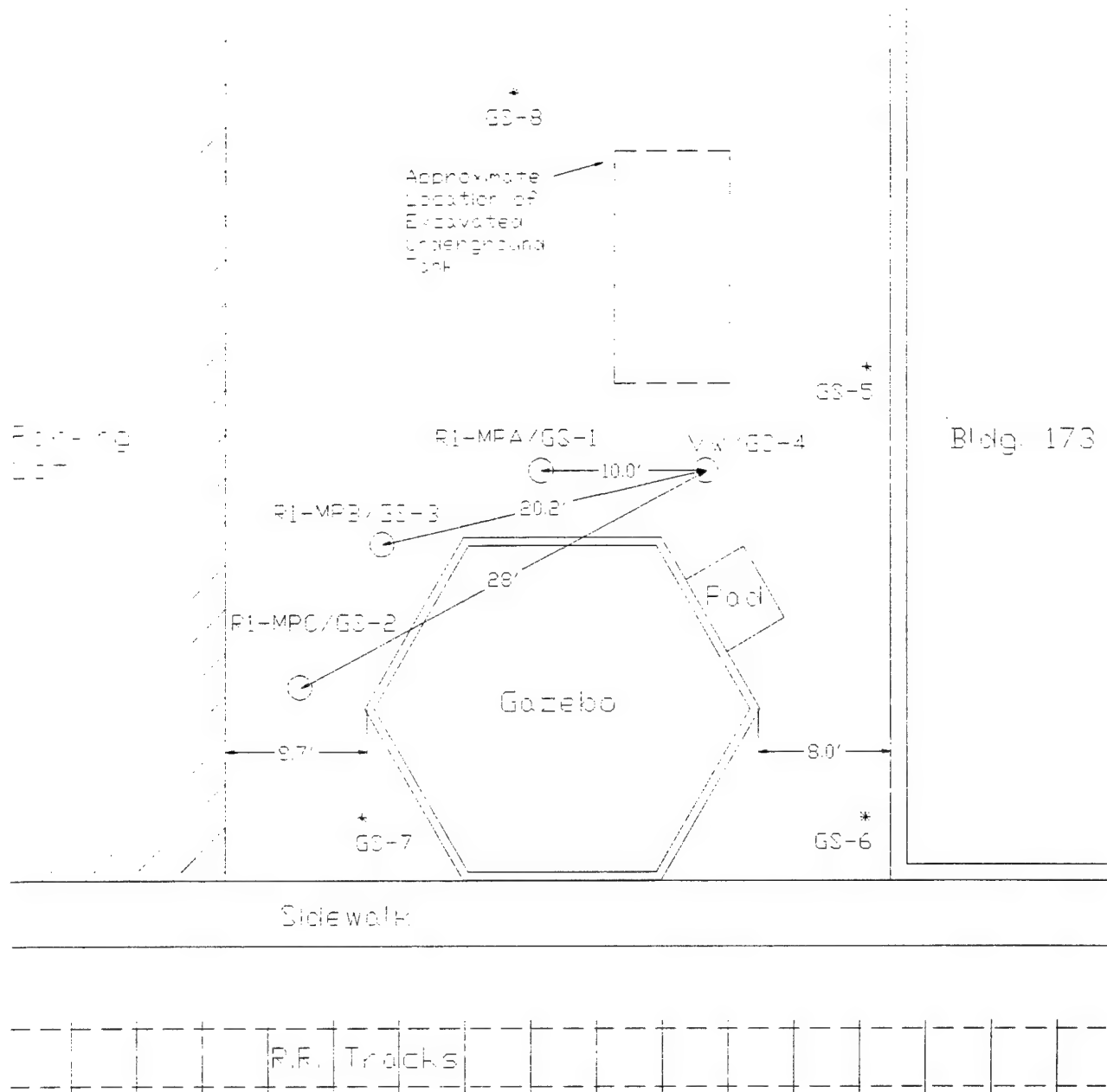


Figure 3. Schematic Diagram of Site UST 173 at Robins AFB (GS - Soil Gas Survey Point; MP - Monitoring Point)

to the tank removal indicated residual soil contamination. The site was re-excavated, and approximately 200 cubic yards of soil were removed for disposal. Soil contamination remained on the southern boundaries of the excavation, but could not be removed without undermining the foundation of a gazebo on site. Soil samples taken from the south wall of the excavation pit exhibited TPH concentrations as high as 22,600 ppm. Elevated concentrations of benzene, toluene, ethylbenzene, and xylenes (BTEX) also were detected. Soil borings taken at the site during a previous site investigation show dense, clayey sand to a depth of approximately 5 feet; coarse sand and gravel to approximately 25 feet; and stiff, tannish white clay below 25 feet. All borings were terminated in the stiff clay, and no groundwater was encountered. No monitoring wells were present at this site; however, based upon general knowledge of groundwater it was estimated that the depth to water was approximately 30 feet.

1.2.3 Site SS-10

A schematic diagram of Site SS-10 is shown in Figure 4. Site SS-10 is located adjacent to a JP-4 jet fuel storage tank farm. Monitoring wells were present on this site, and depth to water ranged from 5 to 19 feet. Free product has been encountered floating on the shallow groundwater, and elevated petroleum hydrocarbon concentrations have been detected in site soils. Concentrations of TPH in soil samples collected during a previous site investigation ranged from 811 up to 3,343 mg/kg, with an average concentration of 2,118 mg/kg.

2.0 SITE 272

A site deemed suitable for the bioventing demonstration should have soil gas characteristics of low oxygen, high carbon dioxide, and high TPH. This composition of soil gas would indicate that oxygen-limiting conditions for microbial activity are present and that the introduction of air may enhance biodegradation of TPH.

A limited soil gas survey was conducted on August 24, 1992 to locate a suitable test area at Site 272. Soil gases were sampled by driving a 5/8-inch-diameter stainless steel probe into the soil with a hammer drill. Soil gas was withdrawn with a vacuum pump and analyzed for oxygen, carbon dioxide, and TPH.

Figure 4. Schematic Diagram of Site SS-10 at Robins AFB (GS - Soil Gas Survey Point; MP - Monitoring Point)

Measurements of oxygen and carbon dioxide in the soil gas were made with a GasTech Model 32530X with oxygen and carbon dioxide ranges of 0 to 25%. The analyzer was calibrated daily against atmospheric oxygen, atmospheric carbon dioxide, a 10% oxygen calibration standard, and a 5% carbon dioxide calibration standard. TPH was measured with a GasTech Trace Techtor with TPH ranges from 0 to 100, 0 to 1,000, and 0 to 10,000 ppm. The GasTech Trace Techtor was calibrated daily against a 4,200-ppm hexane standard.

The soil gas probes were driven to depths ranging from 2.5 to 10.0 feet at several locations at Site 272. Table 1 provides the initial concentrations of oxygen, carbon dioxide, and TPH for the various locations at Site 272. Oxygen concentrations ranged from 5.0 to 21.0%, with the majority of oxygen concentrations above 16%. TPH concentrations were low, with the highest measurements being 200 ppm. These results indicate that there is little contamination at this site, and it is unlikely that installation of a bioventing system would be practical.

3.0 SITE UST 173

3.1 Chronology of Events and Site Activities

3.1.1 Groundwater Measurements

No monitoring wells were present at this site; however, based upon general knowledge of groundwater it was estimated that the depth to water was approximately 30 feet. Soil borings were advanced to approximately 25 feet during this investigation and no groundwater was encountered.

3.1.2 Soil Gas Survey

A limited soil gas survey was conducted on August 25, 1992 to locate a suitable test area at Site UST 173. Soil gases were sampled by driving a 5/8-inch-diameter stainless steel probe into the soil with a hammer drill. Soil gas samples were analyzed as described in Section 2.0.

The soil gas probes were driven to depths ranging from 2.5 to 10.0 feet at several locations at Site UST 173. Table 2 provides the initial concentrations of oxygen, carbon dioxide, and TPH for the various locations at Site UST 173. Oxygen concentrations varied from 0 to 19.2%, whereas TPH

Table 1. Initial Soil Gas Composition at Site 272

Soil Gas Survey Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppm)
GS-1	5	14.0	5.5	155
	7.5	16.5	5.5	200
	10	16.5	6.0	200
GS-2	5	14.8	6.0	180
	7.5	21.0 ¹	0.5	32
	10	21.0 ¹	0.5	45
GS-3	5	16.0	4.2	135
	7.5	18.0	4.0	120
	10	17.0	5.5	150
GS-4	2.5	17.3 ¹	3.8	125
	5	19.0	2.5	110
	7.5	19.5 ¹	2.0	100
	10	20.0 ¹	1.0	120
GS-5	2.5	19.0 ¹	2.5	120
	5	15.0	5.0	130
	7.5	17.0	5.5	140
	10	17.0	5.5	130
GS-6	2.5	15.0	6.0	140
	5	16.5 ¹	6.0	150
	7.5	16.0	6.9	160
GS-7	2.5	12.0	7.5	320
	5	18.0 ¹	4.0	130
	7.5	19.9 ¹	1.9	84
GS-8	2.5	5.0	4.9	120
	5	20.0 ¹	0.8	65
GS-9	2.5	14.9 ¹	6.5	160
	5	20.5 ¹	0.5	40

¹ Pressure reading on sampling pump was high. Measured oxygen concentration may not be representative of actual soil gas oxygen concentrations. Actual oxygen concentration is likely to be lower.

Table 2. Initial Soil Gas Composition at Site UST 173

Soil Gas Survey Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppm)
GS-1	2.5	15.0 ¹	4.5	145
	5	11.7 ¹	6.5	360
	7.5	17.2 ¹	3.0	160
	10	11.0	8.0	620
GS-2	2.5	11.0	7.7	380
	5	19.2 ¹	1.5	240
	7.5	0	9.2	> 20,000
GS-3	2.5	9.5	7.2	380
	5	19.0 ¹	1.5	88
	7.5	12.0 ¹	5.6	230
	10	14.0 ¹	5.5	280
GS-4	2.5	12.3	5.8	360
	5	15.8 ¹	2.3	> 10,000
	7.5	18.0 ¹	1.0	1,200
	10	11.5	7.5	380
GS-5	2.5	17.0 ¹	3.8	40
GS-6	2.5	8.5	9.5	100
	5	15.0 ¹	4.2	84
GS-8	2.5	13.8 ¹	2.5	100
	5	17.5	4.1	0

¹ Pressure reading on sampling pump was high. Measured oxygen concentration may not be representative of actual soil gas oxygen concentrations. Actual oxygen concentration is likely to be lower.

concentrations ranged from 0 to greater than 20,000 ppm. These results indicate that, although not all areas of the site are oxygen-limited, some areas may respond to bioventing.

3.1.3 Vent Well, Monitoring Point, and Thermocouple Installation

On August 26, 1992, the vent well (VW) and three monitoring points (MPs) were installed at Site UST 173, and collection of soil samples for analyses was begun. The monitoring points were labeled R1-MPA, R1-MPB, and R1-MPC. The locations of the vent well and monitoring points are shown in Figure 3. A cross section of the vent well and monitoring points showing site lithology and construction detail is shown in Figure 5.

The vent well was installed at a depth of 23.3 feet into an 8-inch-diameter borehole. The vent well consisted of Schedule 40 2-inch-diameter polyvinyl chloride (PVC) piping with 10 feet of ten-slot screen. The annular space corresponding to the screened area of the well was filled with silica sand; the annular space above the screened interval was filled with bentonite to prevent short-circuiting of air to or from the surface.

Soil gas probes consisted of 1/4-inch tubing with a 1-inch-diameter, 6-inch screened area. The annular space corresponding to the screened area was filled with silica sand. The interval between the screened areas was filled with bentonite, as was the annular space from the shallowest monitoring point to the ground surface. The monitoring points were installed at depths as follows:

- Monitoring point R1-MPA was installed at a depth of 22.3 feet into an 8-inch-diameter borehole. The monitoring point was screened to three depths: 6.8, 14.25, and 21.8 feet.
- Monitoring point R1-MPB was installed at a depth of 23.5 feet into an 8-inch-diameter borehole. The monitoring point was screened to three depths: 8.0, 15.0, and 23.0 feet.
- Monitoring point R1-MPC was installed at a depth of 23.5 feet into an 8-inch-diameter borehole. The monitoring point was screened to three depths: 8.0, 15.0, and 23.0 feet.

A Type J thermocouple was installed with monitoring points R1-MPA-6.8' and R1-MPA-21.8'.

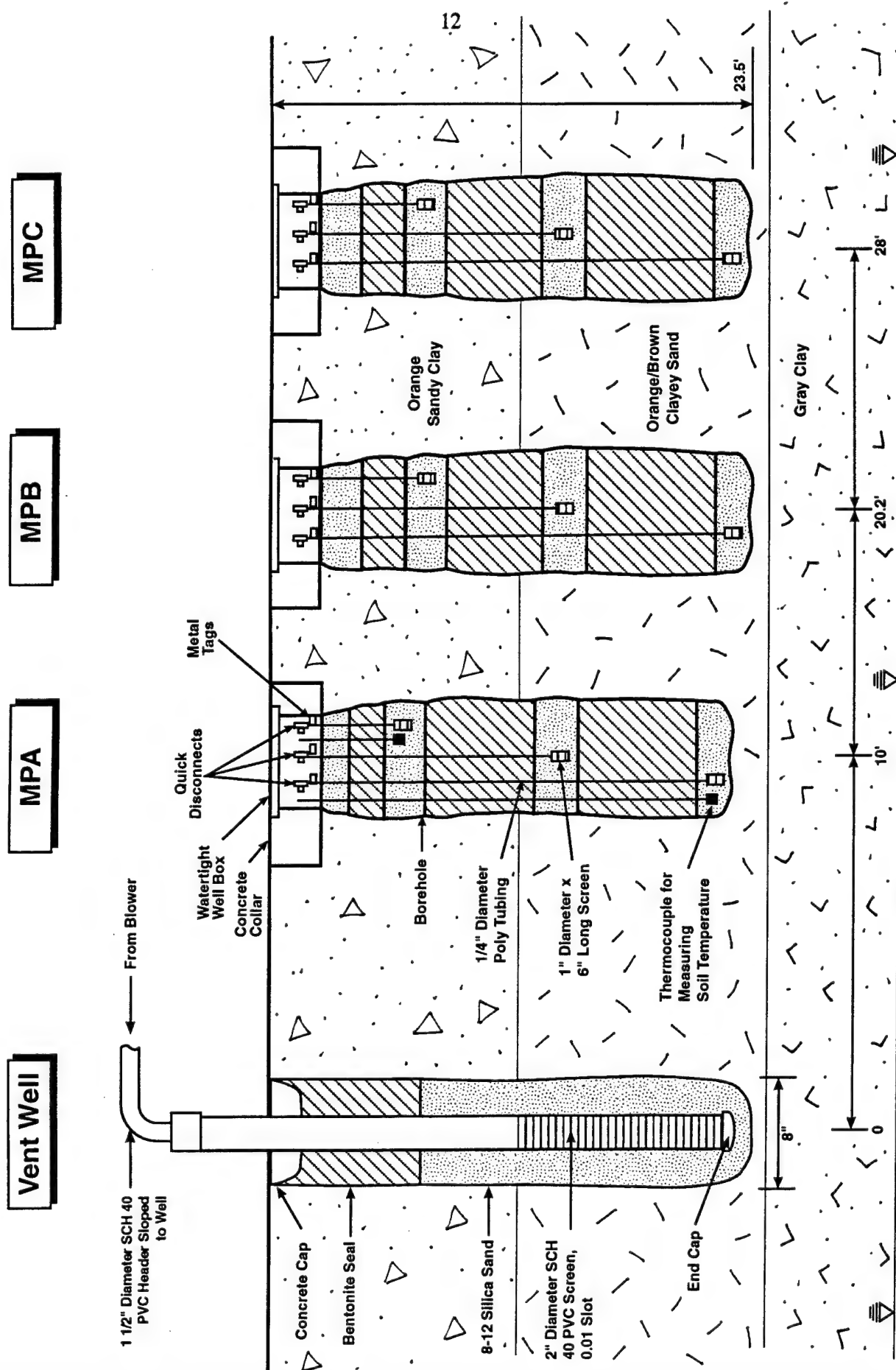


Figure 5. Cross Section of Vent Well and Monitoring Points at Site UST 173 Showing Site Lithology and Construction Detail (not to scale)

3.1.4 Soil and Soil Gas Sampling and Analyses

Soil boring samples were collected from the Site UST 173 vent well borehole at depths of 4.0 to 4.5, 18.0 to 18.5 feet, and 18.5 to 19.0 feet and were labeled R1-V-4.0'-4.5', R1-V-18', and R1-V-18.5'-19', respectively. A soil sample also was taken from monitoring point R1-MPA at a depth of 8.5 to 10.0 feet and labeled R1-A-8.5'-10'. The soil samples were sent under chain of custody to Engineering-Science, Inc., Berkeley Laboratory for analyses of BTEX, TPH, alkalinity, moisture content, pH, iron, total phosphorous, total Kjeldahl nitrogen, and particle size.

Soil gas samples were collected from the vent well, from monitoring points R1-MPA-21.8' and R1-MPC-15.0', and of ambient air. These samples were labeled R1-V, R1-A, R1-C, and ambient, respectively. These samples were sent under chain of custody to Air Toxics, Ltd., in Rancho Cordova, California, for analyses of BTEX and TPH.

3.1.5 Soil Gas Permeability and Radius of Influence

A detailed description of the method for conducting a soil gas permeability test, including equations to compute k , the soil gas permeability, is given in the Test Plan and Technical Protocol (Hinchee et al., 1992).

The monitoring points at Site UST 173 were allowed to set up for 24 hours prior to air injection. A portable 1-horsepower (HP) explosion-proof positive displacement blower unit was used to inject air. After air injection was initiated, pressure readings were taken approximately every 1 to 2 minutes for the first hour, then approximately every 10 minutes for the following hour. The Hyperventilate™ computer model was used to calculate the soil gas permeability.

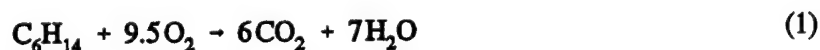
3.1.6 In Situ Respiration Test

Immediately following the soil gas permeability test at Site UST 173, air containing approximately 1% helium was injected into the soil for approximately 24 hours beginning on September 1, 1992. Air was injected concurrently into the background monitoring well to measure the natural biodegradation of organic material in the soil. The setup for the in situ respiration test was as described in the Test Plan and Technical Protocol (Hinchee et al., 1992). The pump used for air injection was a ½-HP diaphragm pump. Air and helium were injected through monitoring points

R1-MPA-14.25', R1-MPA-21.8', R1-MPC-15.0', and R1-MPC-23.0' at the depths indicated by the labels. After the air/helium injection was turned off, the respiration gases were monitored periodically. The respiration test was terminated on September 8.

Helium concentrations were measured during the in situ respiration test to quantify helium leakage to or from the surface around the monitoring points. Helium loss over time is attributed to either diffusion or leakage. A rapid drop in helium concentration followed by a leveling is an indication of leakage. A gradual loss along with an apparent first-order curve is an indicator of diffusion. As a rough estimate, the diffusion of gas molecules is inversely proportional to the square root of the molecular weight of the gas. Based on molecular weights of 4 for helium and 32 for oxygen, helium diffuses about 2.8 times faster than oxygen, or the diffusion of oxygen is 0.35 times the rate of helium diffusion. As a general rule, we have found that if helium concentrations are at least 50% to 60% of the initial levels at test completion, measured oxygen uptake rates are representative. Greater helium loss indicates a problem, and oxygen utilization rates are not considered representative.

To compare data from one site to another, a stoichiometric relationship of the oxidation of the hydrocarbon was assumed. Hexane was used as the representative hydrocarbon for the organic contaminant. The stoichiometric relationship is given by:



Based on the utilization rates (% per day), the biodegradation rates in terms of milligrams as a hexane equivalent per kilogram of soil per day were computed using the equation below by assuming a soil porosity of 0.2 and a bulk density of 1,440 kg/m³.

$$K_b = \frac{-K_o A D_o C}{100} \quad (2)$$

- where: K_b = biodegradation rate (mg/kg/day)
- K_o = oxygen utilization rate (percent per day)
- A = volume of air/kilogram of soil, in this case $300/1,440 = 0.21$
- D_o = density of oxygen gas (mg/L) assumed to be 1,330 mg/L

C = mass ratio of hydrocarbon to oxygen required for mineralization, assumed to be 1:3.5 from the above stoichiometric equation.

3.2 Results and Discussion

3.2.1 Soil and Soil Gas Analyses

Results of the soil analyses for BTEX and TPH at Site UST 173 are presented in Table 3. Relatively low concentrations of the BTEX compounds were found in soil samples, with concentrations ranging from below the detection limit up to 3.0 mg/kg (total xylenes). TPH concentrations were high in sample R1-A-8.5'-10' (5,700 mg/kg), whereas the other soil samples contained relatively low TPH concentrations. The soil gas analyses also showed relatively low BTEX and TPH concentrations with concentrations ranging from less than the detection limit up to 2.2 ppmv (total xylenes) and from 27 to 300 ppmv of TPH (Table 3). The results from the soil chemistry analyses are summarized in Table 4. The laboratory report for the BTEX, TPH, and the soil chemistry analyses is given in Appendix B.

3.2.2 Soil Gas Permeability and Radius of Influence

The raw data for the soil gas permeability test at Site UST 173 are presented in Appendix C. Using the Hyperventilate™ computer model, soil gas permeabilities were calculated at each of the monitoring points. These data are presented in Table 5. The soil gas permeability varied considerably between points with values ranging from 3.8 up to 2.2×10^9 darcy. Typically, the radius of influence is calculated by plotting the log of the pressure change at a specific monitoring point versus the distance from the vent well. The radius of influence would then be the distance where 1 inch of water pressure can be measured. However, in this instance, 1 inch of water pressure was not achieved at any monitoring point (Figure 6); therefore, a radius of influence based on these specifications cannot be definitively determined at this site, other than to say it is less than 10.0 feet.

Table 3. Results From Soil and Soil Gas Analyses for BTEX and TPH at Site UST 173

Matrix	Sample Name	Benzene (mg/kg)	Toluene (mg/kg)	Ethylbenzene (mg/kg)	Total Xylenes (mg/kg)	TPH ¹ (mg/kg)
Soil	R1-V-4.0'-4.5'	<0.29	<0.33	0.33	3.0	37
	R1-V-18.5'-19'	<0.0007	<0.0008	<0.0006	0.0037	8.0
	R1-A-8.5'-10'	<0.0007	0.002	0.009	0.079	5,700
Matrix	Sample Name	Benzene (ppmv)	Toluene (ppmv)	Ethylbenzene (ppmv)	Total Xylenes (ppmv)	TPH ² (ppmv)
Soil Gas	R1-V	<0.004	0.025	0.31	2.2	300
	R1-A	<0.002	0.052	0.055	0.81	290
	R1-C	<0.002	0.006	0.14	0.098	27
	Ambient ³	<0.002	<0.002	<0.002	<0.002	0.20

¹ Referenced to a reference oil composed of a mixture of 2,2,4-trimethylpentane, *n*-hexadecane, and chlorobenzene.

² TPH referenced to jet fuel (molecular weight = 156).

³ Sample taken at R1-MPA.

Table 4. Results From Soil Chemistry Analyses at Site UST 173

Parameter	Sample Name		
	R1-V-4.0'-4.5'	R1-V-18'	R1-A-8.5'-10'
Alkalinity (mg/kg CaCO ₃)	< 50	< 50	< 50
Moisture (% by weight)	16.2	9.1	17.5
pH	4.9	5.4	5.2
Iron (mg/kg)	11,300	4,720	1,980
Total Phosphorous (mg/kg)	110	64	79
Total Kjeldahl Nitrogen (mg/kg)	110	92	68
Particle Size Analysis	Gravel: 0	Gravel: 3	Gravel: 0
	Sand: 49	Sand: 40	Sand: 59
	Silt: 20	Silt: 37	Silt: 22
	Clay: 31	Clay: 20	Clay: 19

Table 5. Results of Hyperventilate™ Soil Gas Permeability Analysis at Site UST 173

Monitoring Point	Depth (ft)	Soil Gas Permeability (darcy)
R1-MPA	6.8	3.8
	14.25	1,000
	21.8	2.2 x 10 ⁹
R1-MPB	8.0	21
	15.0	390
	23.0	380
R1-MPC	8.0	35
	15.0	620
	23.0	780

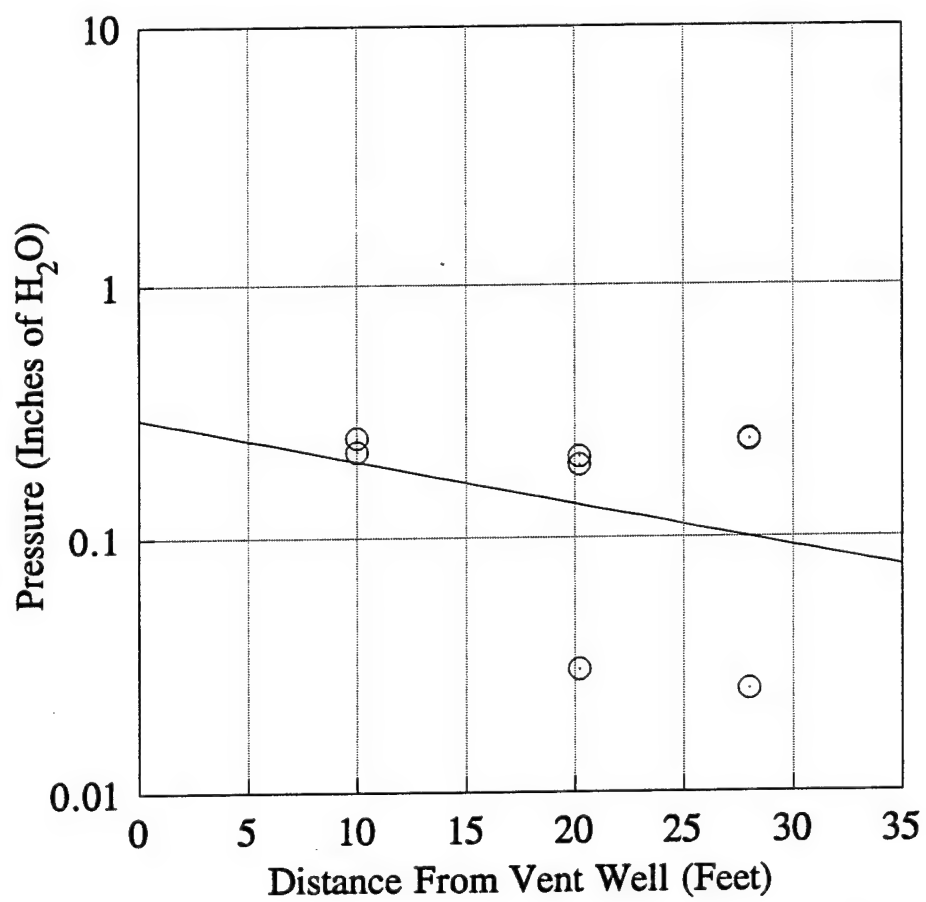


Figure 6. Radius of Influence at Site UST 173

3.2.3 In Situ Respiration Test

The results of the in situ respiration test for Site UST 173 are presented in Appendix D. Each figure in Appendix D illustrates the oxygen, carbon dioxide, and helium concentrations as a function of time. An example of typical oxygen utilization and carbon dioxide production at this site is shown in Figure 7, which shows oxygen, carbon dioxide, and helium at monitoring point R1-MPA-14.25'. Oxygen utilization and carbon dioxide production rates were relatively low at this site at all monitoring points. The rates of oxygen utilization and carbon dioxide production and the corresponding biodegradation rates are summarized in Table 6. The biodegradation rates measured at this site were fairly consistent between the monitoring points, with rates ranging from 0.38 to 0.75 mg/kg/day based upon oxygen and from 0.31 to 0.68 mg/kg/day for carbon dioxide, with a fairly good correlation between the oxygen utilization and carbon dioxide production rates.

Loss of helium was insignificant at all monitoring points, indicating that the monitoring points were well-sealed and that the oxygen depletion observed was a result of biodegradation.

Soil temperatures were measured during the in situ respiration test. Although two thermocouples were installed at this site, only one thermocouple was functioning properly at the time of the test. Temperatures during the test ranged from 25.0°C to 25.4°C at monitoring point R1-MPA-6.8'.

3.2.4 Bioventing Demonstration

The decision was made to install a bioventing system at Site UST 173. The same blower that was used for the soil gas permeability test was installed for the bioventing system. Continuous air injection was initiated on September 4, 1992 at a flowrate of 12 cubic feet per minute (cfm).

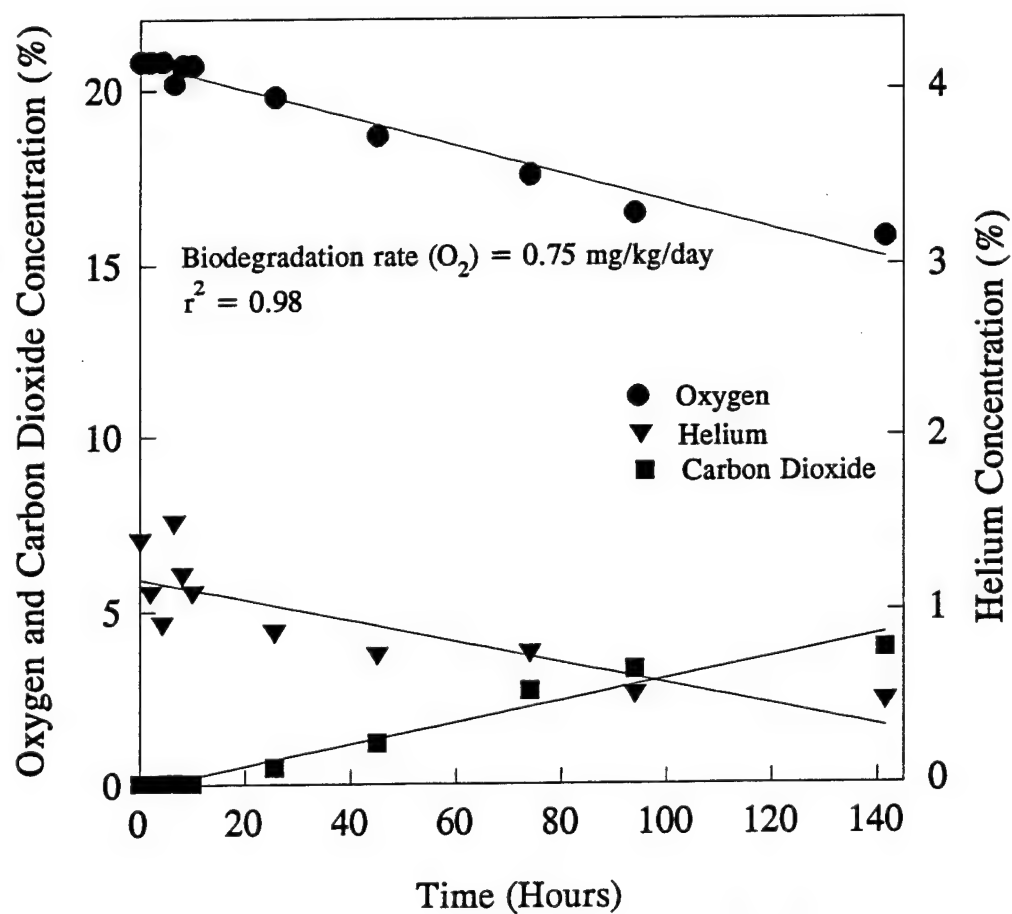


Figure 7. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Site UST 173 Monitoring Point R1-MPA-14.25'

Table 6. Oxygen Utilization and Carbon Dioxide Production Rates During the In Situ Respiration Test at Site UST 173

prior to installation of bioventing system

Monitoring Point	Oxygen Utilization Rate (%/hour)	Biodegradation Rate (mg/kg/day)	Carbon Dioxide Production Rate (%/hour)	Biodegradation Rate (mg/kg/day)
Background	0	0	0	0
R1-MPA-14.25'	0.039	0.75	0.015	0.31
R1-MPA-21.8'	0.028	0.54	0.031	0.68
R1-MPC-15.0'	0.029	0.56	0.024	0.51
R1-MPC-23.0'	0.020	0.38	0.015	0.31

4.0 SITE SS-10

4.1 Chronology of Events and Site Activities

4.1.1 Groundwater Measurements

The groundwater level measured at Well RI-4-JP6W, shown as the existing well in Figure 4, was 7.74 feet. Two other monitoring wells, RI-4-JP7W and LF1-3, were accessible for groundwater measurement, with levels measured at 7.22 and 7.48 feet, respectively.

4.1.2 Soil Gas Survey

A limited soil gas survey was conducted on September 1, 1992 to locate a suitable test area at Site SS-10. Soil gases were sampled by driving a 5/8-inch-diameter stainless steel probe into the soil with a hammer drill. Soil gas was withdrawn with a vacuum pump and analyzed for oxygen, carbon dioxide, and TPH. Measurements of oxygen, carbon dioxide, and TPH in the soil gas were made as described in Section 2.0.

The soil gas probes were driven to depths ranging from 2.5 to 7.5 feet at several locations at Site SS-10. Table 7 provides the initial concentrations of oxygen, carbon dioxide, and TPH for the various locations at Site SS-10. Oxygen concentrations varied from 0 to 20.5%, whereas TPH concentrations ranged from 4 to greater than 20,000 ppm. These results indicate that, although not all areas of the site are oxygen-limited, some areas may respond to bioventing.

4.1.3 Vent Well, Monitoring Point, and Thermocouple Installation

On September 1, 1992, the vent well and three monitoring points were installed at Site SS-10, and collection of soil samples for analyses was begun. The monitoring points were labeled R2-MPA, R2-MPB, and R2-MPC. The locations of the vent well and monitoring points are shown in Figure 4. A cross section of the vent well and monitoring points showing site lithology and construction detail is shown in Figure 8.

The vent well was installed at a depth of 7.25 feet into an 8-inch-diameter borehole. The vent well consisted of Schedule 40 2-inch-diameter PVC piping with 5.0 feet of ten-slot screen from

Table 7. Initial Soil Gas Composition at Site SS-10

Soil Gas Survey Point	Depth (ft)	Oxygen (%)	Carbon Dioxide (%)	TPH (ppm)
GS-1	2.5	20 ¹	0.1	4
	5	0	25	> 20,000
GS-2	2.5	5.0 ¹	6.5	280
	5	20.5 ¹	0.5	230
	7.5	20 ¹	0.6	620
GS-3	2.5	15.8 ¹	5.8	> 10,000
	5	3.0 ¹	20	> 10,000
GS-5	5	0	> 25	> 20,000
GS-6	2.5	1.5	> 25	> 10,000

¹ Pressure reading on sampling pump was high. Measured oxygen concentration may not be representative of actual soil gas oxygen concentrations. Actual oxygen concentration is likely to be lower.

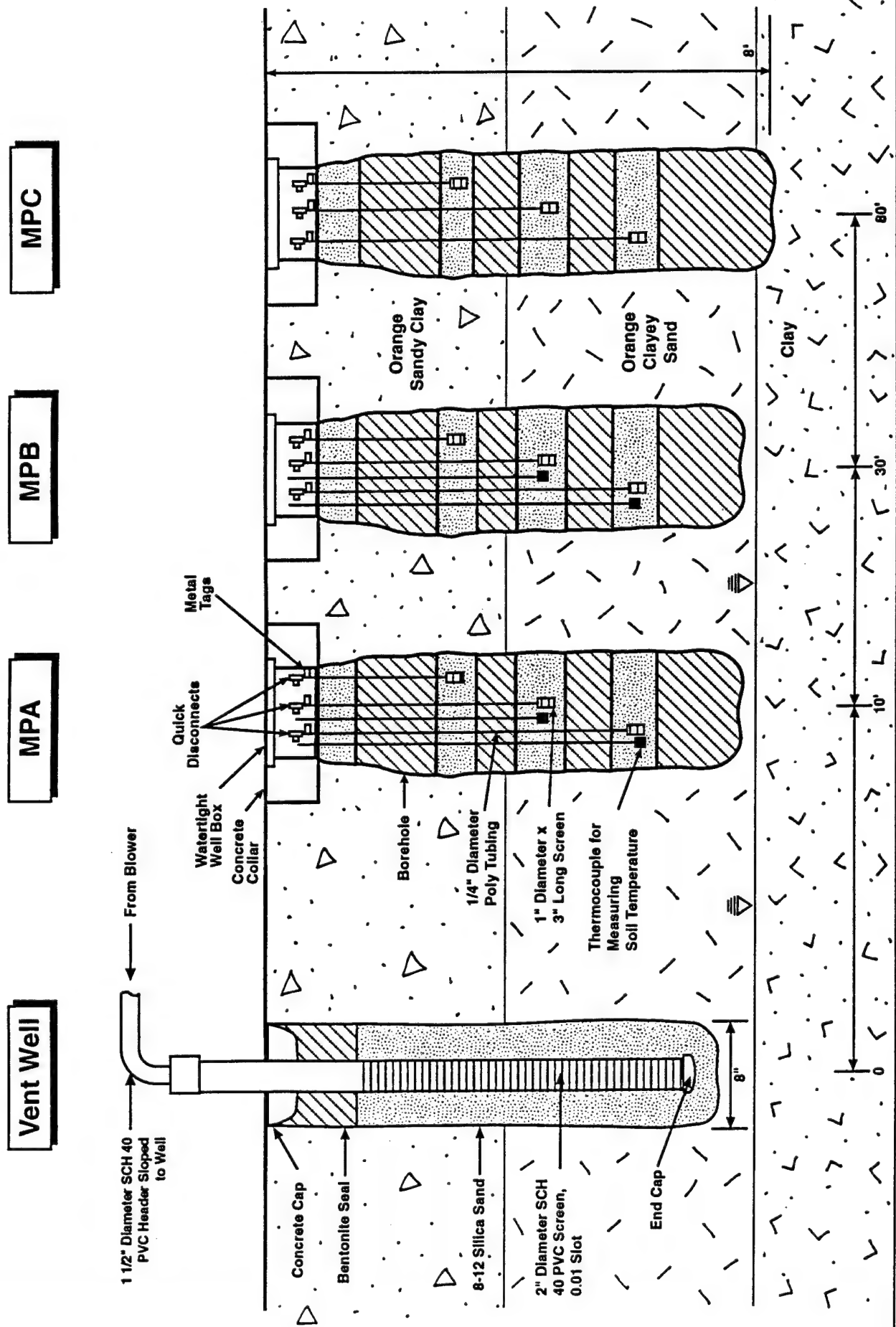


Figure 8. Cross Section of Vent Well and Monitoring Points at Site SS-10 Showing Site Lithology and Construction Detail (not to scale)

2.0 feet to 7.0 feet. The annular space corresponding to the screened area of the well was filled with silica sand; the annular space above the screened interval was filled with bentonite to prevent short-circuiting of air to or from the surface.

Soil gas probes consisted of ¼-inch tubing with a 3-inch screened area 1-inch in diameter. The annular space corresponding to the screened area was filled with silica sand. The interval between the screened areas was filled with bentonite, as was the annular space from the shallowest monitoring point to the ground surface. The monitoring points were installed as follows:

- Monitoring point R2-MPA was installed at a depth of 7.5 feet into an 8-inch-diameter borehole. The monitoring point was screened to three depths: 3.0, 4.5, and 6.0 feet.
- Monitoring point R2-MPB was installed at a depth of 7.5 feet into an 8-inch-diameter borehole. The monitoring point was screened to three depths: 3.0, 4.5, and 6.0 feet.
- Monitoring point R2-MPC was installed at a depth of 8.0 feet into an 8-inch-diameter borehole. The monitoring point was screened to three depths: 3.0, 4.5, and 6.0 feet.

A Type J thermocouple was installed with monitoring points R2-MPA-4.5', R2-MPA-6.0', R2-MPC-4.5', and R2-MPC-6.0'.

4.1.4 Soil and Soil Gas Sampling and Analyses

A soil sample was collected from the Site SS-10 vent well borehole at a depth of 7.25 to 7.75 feet and was labeled R2-V-7'3". Soil samples also were taken from monitoring point R2-MPA at depths of 3.0 to 3.5 feet and from 5.0 to 5.5 feet and were labeled R2-A-3'-3.5' and R2-A-5'-5.5', respectively. The soil samples were sent under chain of custody to Engineering-Science, Inc., Berkeley Laboratory for analyses of BTEX, TPH, alkalinity, moisture content, pH, iron, total phosphorous, total Kjeldahl nitrogen, and particle size.

Soil gas samples were collected from the vent well and from monitoring points R2-MPA-5.0' and R2-MPC-8.0', and of ambient air. These samples were labeled R2-VW, R2-A-5', R2-C-8, and ambient, respectively. These samples were sent under chain of custody to Air Toxics, Ltd., in Rancho Cordova, California, for analyses of BTEX and TPH.

4.1.5 Soil Gas Permeability and Radius of Influence

A detailed description of the method for conducting a soil gas permeability test, including equations to compute k , the soil gas permeability, is given in the Test Plan and Technical Protocol (Hinchee et al., 1992).

The monitoring points at Site SS-10 were allowed to set up for 24 hours prior to air injection. A portable 2.5-HP explosion-proof positive displacement blower unit was used to inject air. After air injection was initiated, pressure readings were taken approximately every 1 to 2 minutes for the first hour, then approximately every 10 minutes for the following hour. The Hyperventilate™ computer model was used to calculate the soil gas permeability.

4.1.6 In Situ Respiration Test

Immediately following the soil gas permeability test at Site SS-10, air containing approximately 1% helium was injected into the soil for approximately 24 hours beginning on September 4. Air was injected concurrently into the background monitoring well to measure the natural biodegradation of organic material in the soil. The setup for the in situ respiration test was as described in the Test Plan and Technical Protocol (Hinchee et al., 1992). The pump used for air injection was a ½-HP diaphragm pump. Air and helium were injected through monitoring points R2-MPA-4.5', R2-MPA-6', R2-MPC-4.5', and R2-MPC-6' at the depths indicated by the labels. After the air/helium injection was turned off, the respiration gases were monitored periodically. The respiration test was terminated on September 9. Results of the in situ respiration were calculated as described in Section 3.1.6.

4.2 Results and Discussion

4.2.1 Soil and Soil Gas Analyses

Results of the soil analyses for BTEX and TPH at Site SS-10 are presented in Table 8. Relatively high concentrations of toluene, ethylbenzene, and xylenes were found in soil samples from the vent well, with concentrations ranging from 39 mg/kg (ethylbenzene) up to 220 mg/kg (total xylenes). Lower concentrations were found at monitoring point A [0.098 mg/kg (toluene) up to 6.8

Table 8. Results From Soil and Soil Gas Analyses for BTEX and TPH at Site SS-10

Matrix	Sample Name	Benzene (mg/kg)	Toluene (mg/kg)	Ethylbenzene (mg/kg)	Total Xylenes (mg/kg)	TPH ¹ (mg/kg)
Soil	R2-V-7'3"	< 1.3	59	39	220	9,000
	R2-A-3'-3.5'	0.053	0.098	0.054	0.54	150
	R2-A-5'-5.5'	< 0.26	0.70	2.0	6.8	58
Matrix	Sample Name	Benzene (ppmv)	Toluene (ppmv)	Ethylbenzene (ppmv)	Total Xylenes (ppmv)	TPH ² (ppmv)
Soil Gas	R2-VW	260	120	11	81	42,000
	R2-A-5'	220	87	14	72	50,000
	R2-C-8	330	120	22	100	72,000
	Ambient ³	< 0.002	< 0.002	< 0.002	< 0.002	0.55

¹ Referenced to a reference oil composed of a mixture of 2,2,4-trimethylpentane, *n*-hexadecane, and chlorobenzene.

² TPH referenced to jet fuel (molecular weight = 156).

³ Sample taken between vent well and R2-MPA.

mg/kg (total xylenes)], and benzene was detected only in sample R2-A-3'-3.5'. TPH concentrations were highest in the soil sample R2-V-7'3" (9,000 mg/kg), whereas concentrations of 58 and 150 mg/kg were detected in the soil samples from monitoring point A. The soil gas analyses also showed high BTEX and TPH concentrations, with concentrations ranging from 11 ppmv (ethylbenzene) up to 330 ppmv (benzene), and from 42,000 to 72,000 ppmv of TPH (Table 8). The results from the soil chemistry analyses are summarized in Table 9. The laboratory report for the BTEX, TPH, and soil chemistry analyses is given in Appendix B.

4.2.2 Soil Gas Permeability and Radius of Influence

The raw data for the soil gas permeability test at Site SS-10 are presented in Appendix E. Using the Hyperventilate™ computer model, soil gas permeabilities were calculated at each of the monitoring points. These data appear in Table 10. The soil gas permeability varied considerably between points with values ranging from 1.7 up to 8.3×10^8 darcy. The radius of influence where 1 inch of pressure was measured was calculated by plotting the log of the pressure change at the monitoring points versus the distance from the vent well (Figure 9). The radius of influence at Site SS-10 is estimated to be approximately 22 feet using a 2-HP blower.

4.2.3 In Situ Respiration Test

The results of the in situ respiration test for Site SS-10 are presented in Appendix F. Each figure in Appendix F illustrates the oxygen, helium, and carbon dioxide concentrations as a function of time. An example of typical oxygen utilization and carbon dioxide production at this site is shown in Figure 10, which shows oxygen, helium, and carbon dioxide at monitoring point R2-MPC-6.0'. These results are typical for oxygen utilization and carbon dioxide production at monitoring point R2-MPC, whereas the rates were somewhat slower at monitoring point R2-MPA. The rates of oxygen utilization and carbon dioxide production and the corresponding biodegradation rates are summarized in Table 11. The biodegradation rates measured at this site ranged from 1.2 to 6.4 mg/kg/day based on oxygen and from 0.19 to 0.57 mg/kg/day based on carbon dioxide. Biodegradation rates based on carbon dioxide production were consistently lower than those calculated based upon oxygen utilization, suggesting that carbon dioxide was reacting chemically in the soil.

Table 9. Results From Soil Chemistry Analyses at Site SS-10

Parameter	Sample Name		
	R2-V-7'3"	R2-A-5'-5.5'	R2-A-3'-3.5'
Alkalinity (mg/kg CaCO ₃)	< 50	< 50	< 50
Moisture (% by weight)	8.2	11.8	9.8
pH	5.2	5.0	5.8
Iron (mg/kg)	1,780	4,070	4,960
Total Phosphorous (mg/kg)	43	81	110
Total Kjeldahl Nitrogen (mg/kg)	37	31	70
Particle Size Analysis	Gravel: 0	Gravel: 0	Gravel: 4
	Sand: 61	Sand: 49	Sand: 57
	Silt: 25	Silt: 25	Silt: 19
	Clay: 14	Clay: 26	Clay: 20

Table 10. Results of Hyperventilate™ Soil Gas Permeability Analysis at Site SS-10

Monitoring Point	Depth (ft)	Soil Gas Permeability (darcy)
R2-MPA	3.0	4.8×10^8
	4.5	8.3×10^8
	6.0	1.7
R2-MPB	3.0	1,200
	4.5	1.8×10^5
	6.0	6.1×10^5
R2-MPC	3.0	79
	4.5	170
	6.0	210

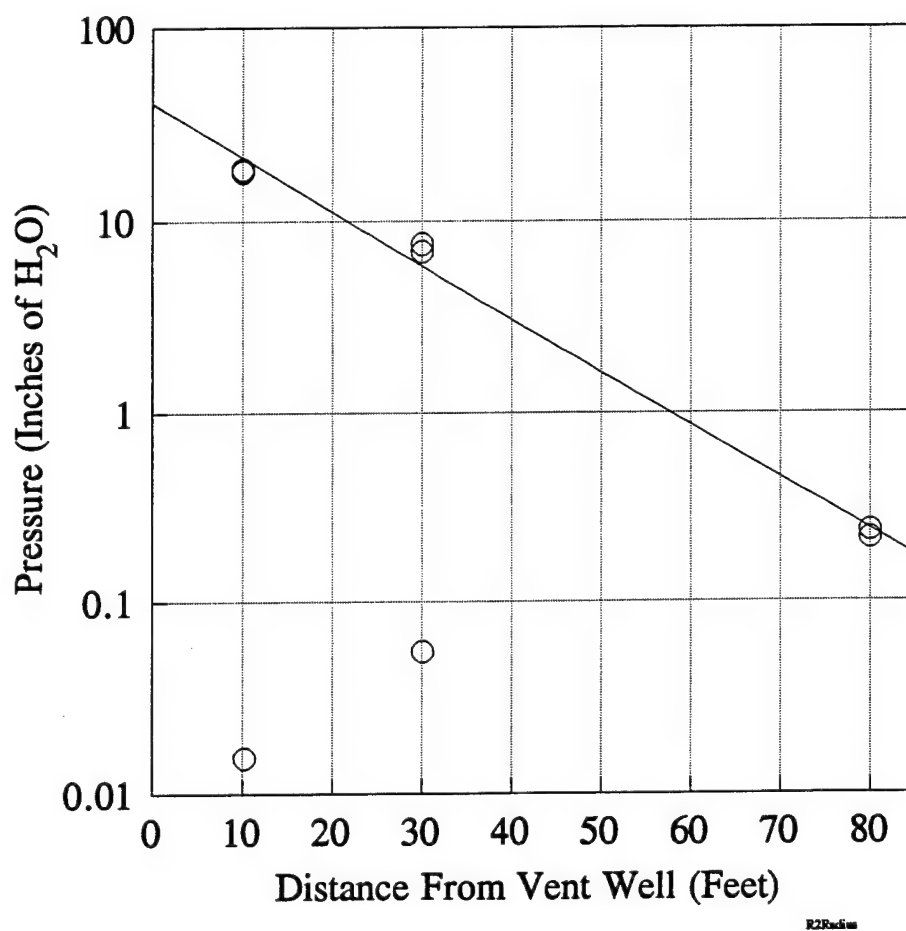


Figure 9. Calculation of Radius of Influence at Site SS-10

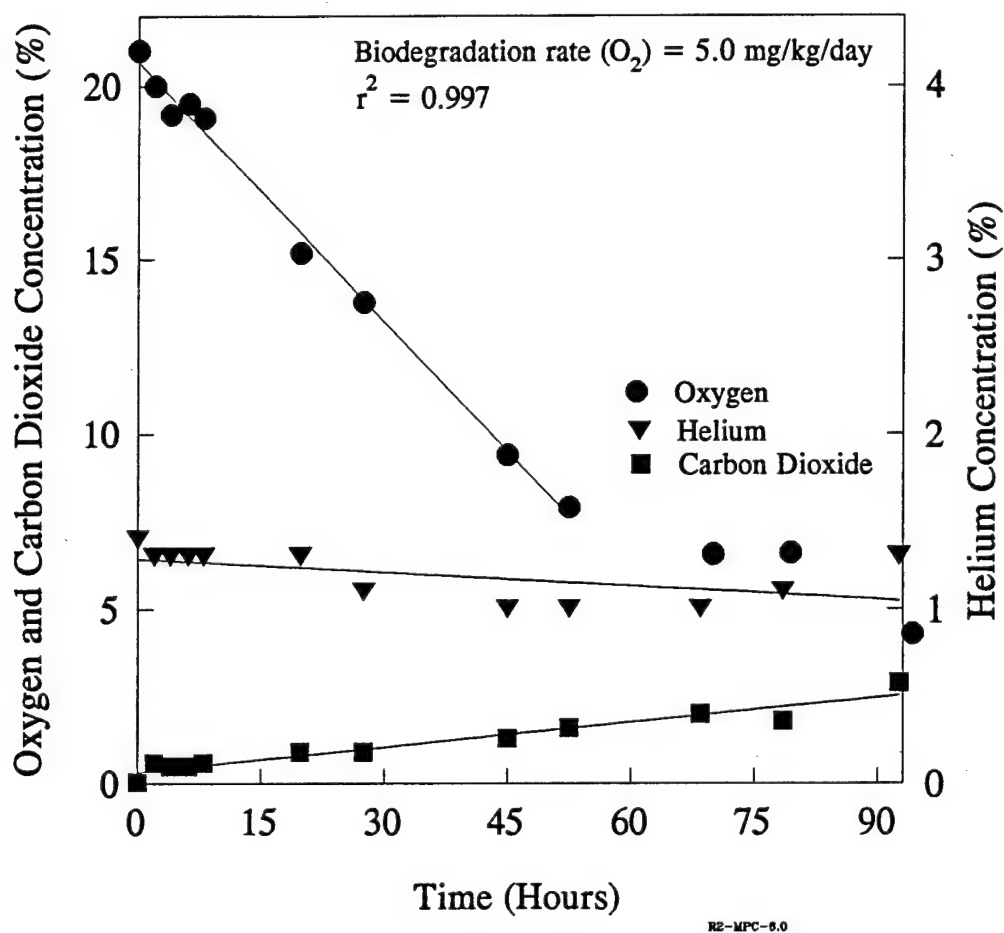


Figure 10. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Site SS-10 Monitoring Point R2-MPC-6.0'

Table 11. Oxygen Utilization and Carbon Dioxide Production Rates During the In Situ Respiration Test at Site SS-10

Monitoring Point	Oxygen Utilization Rate (%/hour)	Biodegradation Rate (mg/kg/day)	Carbon Dioxide Utilization Rate (%/hour)	Biodegradation Rate (mg/kg/day)
Background	0	0	0	0
R2-MPA-4.5'	0.061	1.2	0.0086	0.19
R2-MPA-6.0' ?	0.074 ?	1.4 ?	0.0095	0.20
R2-MPC-4.5'	0.34 ?	6.4 ?	0.024	0.51
R2-MPC-6.0'	0.26	5.0	0.026	0.57

Loss of helium was insignificant at all monitoring points, indicating that the monitoring points were well sealed and that the oxygen depletion observed was a result of biodegradation.

Soil temperatures were measured at two thermocouples during the in situ respiration test. Temperatures during the test ranged from 26.3°C to 28.4°C at monitoring point R2-MPA-4.5' and from 25.2°C to 26.8°C at monitoring point R2-MPA-6.0'.

4.2.4 Bioventing Demonstration

The decision was made to install a bioventing system at Site SS-10. The same blower that was used for the soil gas permeability test was installed for the bioventing system. Continuous air injection was initiated on September 10 at a flowrate of 27 cfm.

5.0 BACKGROUND AREA

A background vent well was installed on August 31, 1992 at the location shown in Figure 1. The depth of this vent well was 23 feet. Ten feet were screened using Schedule 40, 2-inch-diameter, 10-slot PVC, and the remaining 13 feet consisted of Schedule 40, 2-inch-diameter PVC riser. The first 15 feet of the vent well were surrounded by sand, and 6 of the remaining 8 feet were enclosed

by bentonite to seal the vent well. The site lithology in this area was similar to that found at the contaminated sites.

An in situ respiration test was conducted at the background area beginning on September 5 after 24 hours of air injection. The test was concluded on September 9. No significant biodegradation was detected in this area, as shown in Figure 11.

6.0 FUTURE WORK

Base personnel will be required to perform a simple weekly system check to ensure that the blower is operating within its intended flowrate, pressure, and temperature range. An on-site briefing was conducted for base personnel who will be responsible for blower system checks. The principle of operation was explained, and a simple checklist and logbook were provided for blower data. Base personnel will perform minor maintenance activities, such as replacing filters or gauges, or draining condensate from knockout chambers, but they will not be expected to perform complicated repairs or analyze gas samples. Replacement filters and gauges will be provided and shipped to the base and serious problems, such as motor or blower failures, will be corrected by Battelle.

The progress of this system will be monitored by conducting semiannual respiration tests in the vent well and in each monitoring point, and by regularly measuring the oxygen, carbon dioxide, and hydrocarbon concentrations in the extracted soil gas and comparing them to background levels. At least twice each year, the progress of the bioventing test will be reported to the base point-of-contact.

7.0 REFERENCE

Hinchee, R.E., S.K. Ong, R.N. Miller, D.C. Downey, and R. Frandt. 1992. *Test Plan and Technical Protocol for a Field Treatability Test for Bioventing* (Rev. 2), Report prepared by Battelle Columbus Operations, U.S. Air Force Center for Environmental Excellence, and Engineering-Science, Inc. for the U.S. Air Force Center for Environmental Excellence, Brooks Air Force Base, Texas.

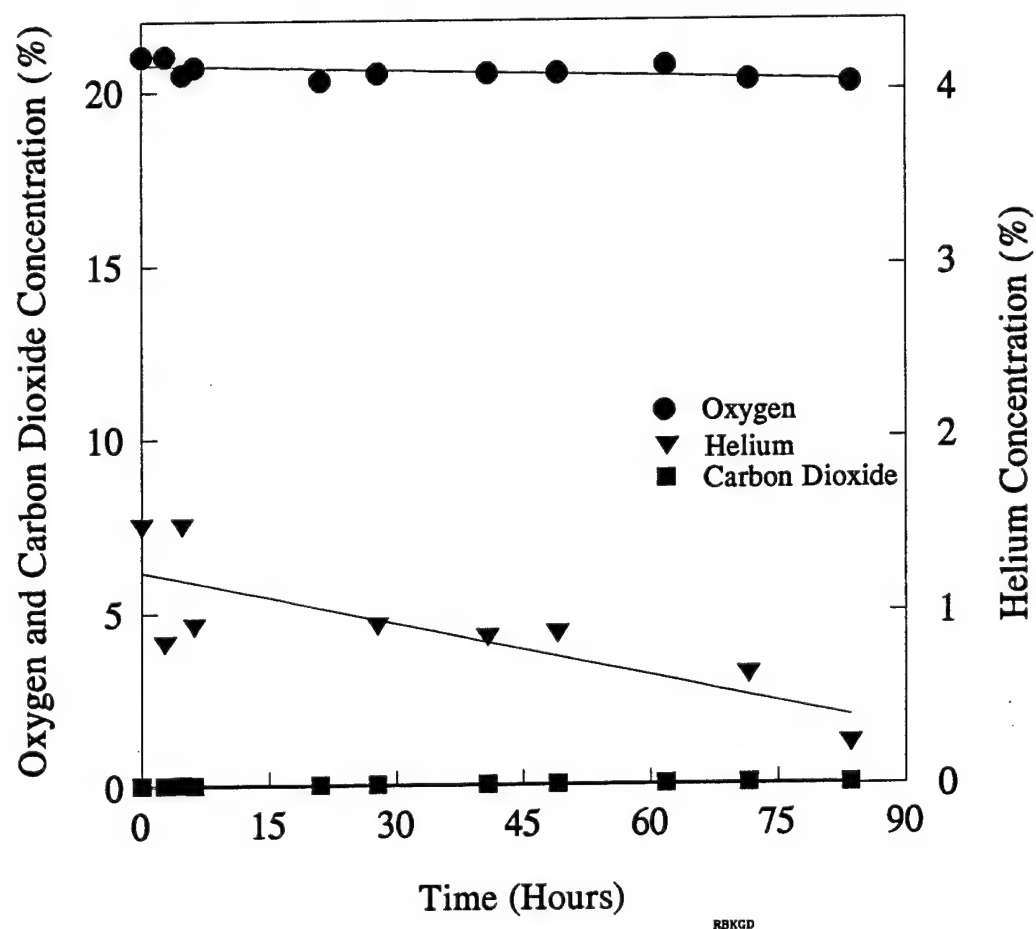


Figure 11. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at the Background Area

APPENDIX A
TEST PLAN FOR ROBINS AFB, GEORGIA

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July 20, 1992

Captain Catherine Vogel
HQ AFCESA/RAVW
139 Barnes Drive
Tyndall AFB, Florida 32403-5319

**SUBJECT: TEST PLAN FOR BIOVENTING INITIATIVE FIELD TEST
AT USTS 173, 272 AND SITE SS10, ROBINS AFB, GA**

Dear Cathy:

Attached is the report "Test Plan and Technical Protocol for a Field Treatability Test for Bioventing." This document was developed as a generic test plan for the Air Force Bioventing Initiative Project in which Robins AFB is participating. This letter outlines site specific information to support the generic test plan.

The sites chosen for the bioventing test initiative are UST site 173, UST site 272, and JP-4 spill site SS10. The tanks at UST sites 173 and 272 were both abandoned in place for a number of years before being removed October 18, 1989. Site SS10 is a JP-4 spill site with free product present on the shallow water table.

The purpose of this project is to investigate the feasibility of using the bioventing technology to remediate petroleum-contaminated soils at the above mentioned sites.

Site descriptions

Robins AFB is located approximately 10 miles south of Macon, Georgia, adjacent to the town of Warner Robins, GA. A map of Robins is shown in Figure 1. Summaries of the available descriptions of each site proposed for the Bioventing Initiative are presented below.

Site UST 173 - This site consisted of a 1500 gallon diesel tank abandoned in place approximately 20 years ago. The tank was removed in October 1989. Site investigation activities conducted subsequent to the tank removal indicated residual contamination. The site was re-excavated and approximately 200 cubic yards of soil were removed for disposal. Soil

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GEORGIA

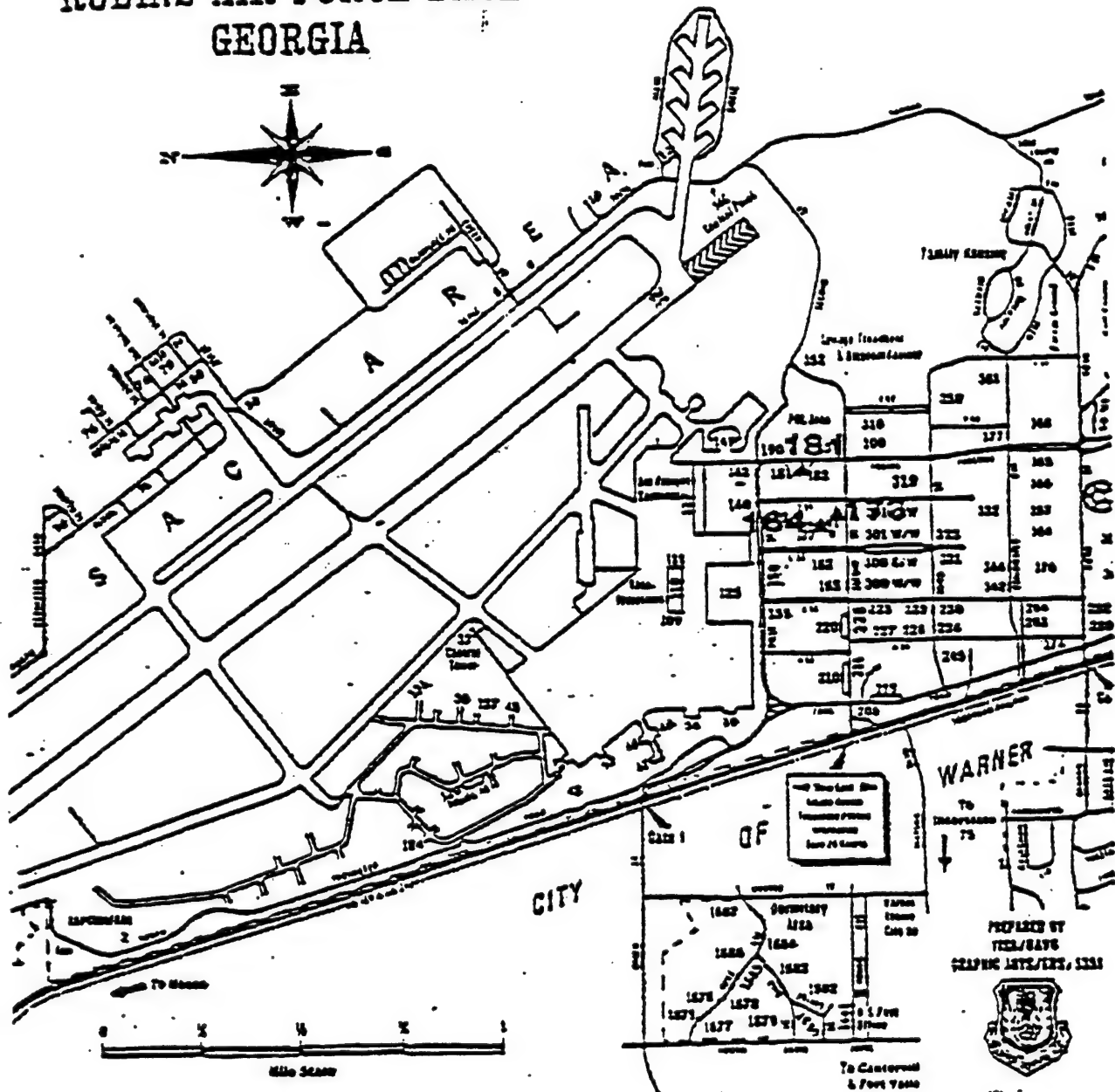


FIGURE 1. BASE MAP OF ROBINS AFB, GA.

contamination remained on the southern boundaries of the excavation but could not be removed without undermining the foundation of a gazebo on site. Soil samples taken from the south wall of the excavation pit exhibited total petroleum hydrocarbon (TPH) concentrations as high as 22,600 ppm. Elevated BTEX (benzene, toluene, ethylbenzene, and xylenes) concentrations were also detected. Tables 1 and 2 present the analytical data for site UST 173. Figures 2 and 3 are site diagrams of UST 173 showing soil sampling locations for Tables 1 and 2, respectively. Soil borings taken at the site during the site investigation show dense, clayey sand to approximately 5 ft., coarse sand and gravel to approximately 25 ft, and stiff tannish white clay below 25 ft. All borings were terminated in the stiff clay and no groundwater was encountered. A representative soil boring is shown in Figure 4.

Site UST 272 - This site consisted of a 250 gallon diesel tank abandoned in place approximately 10 years ago. The tank was removed in October of 1989. Soil sampling performed after the tank removal has indicated TPH concentrations in excess of 2000 ppm in some locations. A site sketch showing sampling locations is shown in Figure 5 and associated analytical results are presented in Table 3. Soil boring logs were not available for the site, but based on observations during tank removal, site geology is likely to be similar to UST 173.

Site SS10 - This site is located adjacent to a JP-4 fuel storage tank farm. Unlike sites UST 173 and UST 272 groundwater is present on this site at depths ranging from 5 to 19 ft. Free product has been encountered floating on the shallow groundwater and elevated petroleum hydrocarbon concentrations have been detected in site soils (see Table 4). Figure 6 shows the location of JP-4 spill site SS10. Figure 7 presents the estimated extent of the free product plume. Figure 8 shows a representative geologic cross-section of the spill site.

Project activities

The following field activities are planned for the bioventing project at Robins AFB. The same procedures will be followed at each site. Additional details can be found in Section 5.0 of the attached test plan and technical protocol.

- A small scale soil gas survey will be conducted to identify an appropriate location for installation of the bioventing system. The soil gas survey will be conducted in areas which site data have shown to be the most contaminated. Soil vapor from the candidate site should exhibit high petroleum hydrocarbon concentrations (10,000 ppm or greater), relatively low O₂ concentrations (0 % to 2.0 %), and relatively high CO₂ concentrations (depending on soil type, 2.0 % to 10.0 %, or higher). An uncontaminated background location will also be identified.
- Once the installation sites are located one vent well and three 3-level soil gas monitoring points will be installed in the contaminated location and one vent well will be installed in the background area (one background area will be used for all

TABLE 1. UST CAVITY CONTAMINANT CONCENTRATIONS AT UST SITE 173, ROBINS AFB, GA.

CONCENTRATION
(mg/Kg)

SAMPLE LOCATION	DEPTH(ft)	TPH	BENZENE	TOLUENE	ETHYLBENZENE	XYLENE
#1	8	122	<.010	<.010	<.010	<.020
#2	8	187	<.010	<.040	<.010	<.020
#3	8	50	<.010	<.020	<.010	<.020
#4	8	34	<.010	<.020	<.010	<.020
#5	8	41	<.010	<.020	<.010	<.020
#6	8	22600	<.100	1.87	17.30	239.00
#7	8	3670	<200	0.60	3.05	43.30
#8	8	24	<.010	<.020	<.010	<.020
#9	8	29	<.010	<.040	<.010	<.020

#1

#2

#6

#7

TABLE 2. SOIL BORING CONTAMINANT CONCENTRATIONS AT UST SITE 173, ROBINS AFB

CONCENTRATION
(mg/Kg)

SAMPLE LOCATION	DEPTH(ft)	TPH	BENZENE	TOLUENE	ETHYLBENZENE	XYLENE
173-B1-2	8.5-10.0	NA	BDL	BDL	BDL	89.42
173-B1-3	13.5-15	NA	BDL	0.51	0.22	0.11
173-B1-4	18.5-20.0	NA	BDL	0.24	BDL	0.13
173-B1-5	23.5-25.0	NA	BDL	BDL	BDL	BDL
173-B2-3	13.5-15	NA	BDL	BDL	BDL	BDL
173-B4-3	13.5-15	NA	BDL	BDL	BDL	BDL
173-B5-2	8.5-10.0	NA	BDL	0.23	0.53	0.27
173-B6-2	8.5-10.0	NA	BDL	BDL	BDL	BDL
173-B8-3	13.5-15	NA	BDL	0.22	BDL	0.43
173-B9-3	13.5-15	NA	BDL	0.20	0.52	0.27

BDL - BELOW DETECTION LIMIT

NA - NOT APPLICABLE (sample analyzed for BTEX only)

173-B1-2

TABLE 3. CONTAMINANT CONCENTRATIONS AT UST SITE 272, ROBINS AFB, GA.

CONCENTRATION
(mg/Kg)

SAMPLE LOCATION	DEPTH(ft)	TPH	BENZENE	TOLUENE	ETHYLBENZENE	XYLENE
1A	10	<40	NA	NA	NA	NA
2A	3	2810	NA	NA	NA	NA
3A	10	<40	NA	NA	NA	NA
4A	10	<40	NA	NA	NA	NA
5A	10	<40	NA	NA	NA	NA
A23 *	3	738	NA	NA	NA	NA
A23 *	6	547	NA	NA	NA	NA
A23 *	10	310	NA	NA	NA	NA
A23 *	15	141	NA	NA	NA	NA
A24 *	3	89.8	NA	NA	NA	NA
A24 *	5	1090	NA	NA	NA	NA
A25 *	5	134	NA	NA	NA	NA
A25 *	10	<20	NA	NA	NA	NA
A25 *	15	<20	NA	NA	NA	NA
A26 *	6	<20	NA	NA	NA	NA
A26 *	10	<20	NA	NA	NA	NA
A26 *	15	<20	NA	NA	NA	NA

BDL - BELOW DETECTION LIMIT

NA - NOT APPLICABLE (sample analyzed for TPH only)

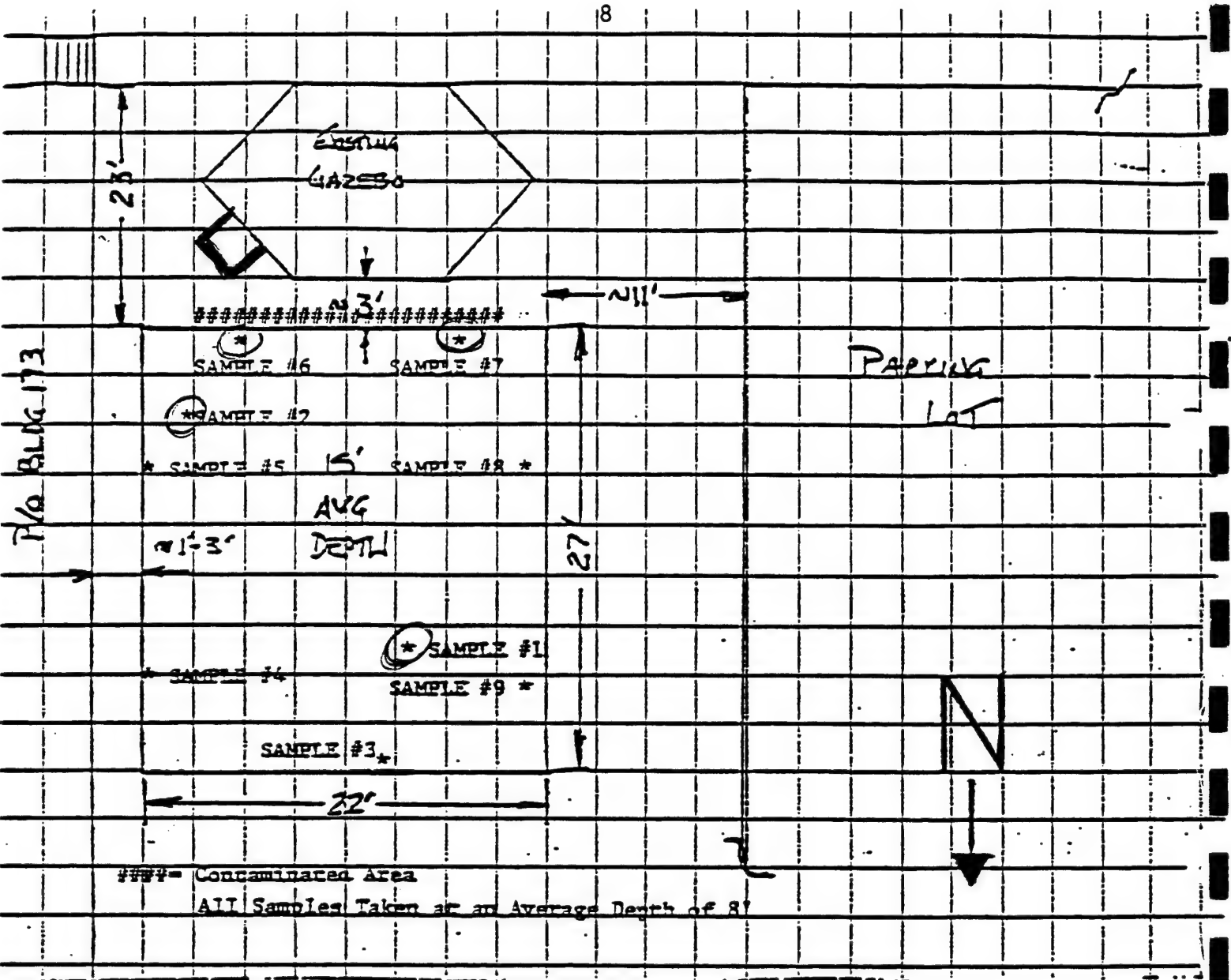
* - CONCENTRATIONS WERE EXPRESSED AS mg/L, HAVE ASSUMED mg/Kg WAS INTENDED

TABLE 4. CONTAMINANT CONCENTRATIONS AT JP-4 SPILL SITE SS10, ROBINS AFB, GA.

CONCENTRATION
(mg/Kg)

SAMPLE LOCATION	DEPTH(ft)	TPH	BENZENE	TOLUENE	ETHYLBENZENE	XYLENE
RI4-1	NR	28	1.10	0.59	0.09	0.51
RI4-2	NR	BDL	BDL	BDL	BDL	BDL
RI4-3	NR	BDL	BDL	BDL	BDL	BDL
RI4-4	NR	6990	4.60	22.00	26.00	170.00
RI4-5	NR	BDL	BDL	BDL	BDL	BDL
RI4-6	NR	594	0.07	0.13	0.04	0.20
RI4-7	NR	10100	11.00	70.00	38.00	20.00
RI4-8	NR	1550	5.60	43.00	24.00	160.00

BDL - BELOW DETECTION LIMIT
NR - NOT REPORTED

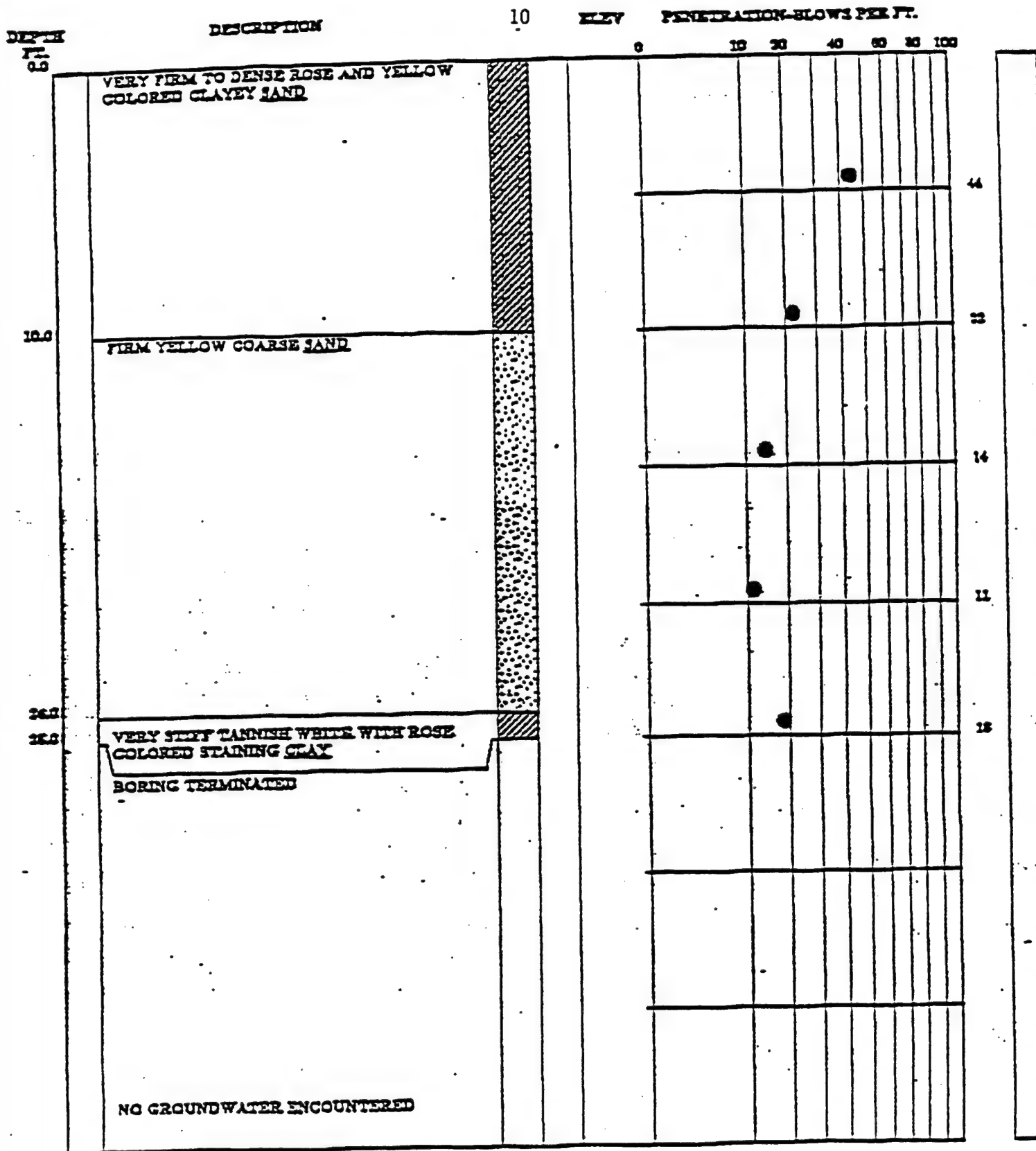


Excavate and stockpile top 5 feet of soil.
 Remove and dispose of soil from 5 feet to 15 feet depth.
 Excavate an area to include but not exceed, 27 feet on
 the east and west side and 22 feet on the north and south side.
 The contaminated soil excavated and disposed of should
 not exceed a total value of 220 cubic yards.
 The site is located 23 feet from the southwest corner
 of Bldg. 173 and 2 feet west.

FIGURE 2. TANK EXCAVATION SAMPLE LOCATIONS - UST 173.



FIGURE 3. SOIL BORING LOCATIONS - UST 173.



BORING AND SAMPLING - ASTM D-1586
CORE DRILLING - ASTM D-3113

PENETRATION IS THE NUMBER OF BLOWS OF 140 LB. HAMMER
FALLING 30 IN. REQUIRED TO DRIVE 1.4 IN. LD. SAMPLER 1 FT.

UNDISTURBED SAMPLE

% ROCK CORE RECOVERY

WATER TABLE 24 HR.

WATER TABLE, T.O.D.

LOSS OF DRILLING WATER

TEST BORING RECORD

BORING NO. 173-9 (pg. 1 of 1)

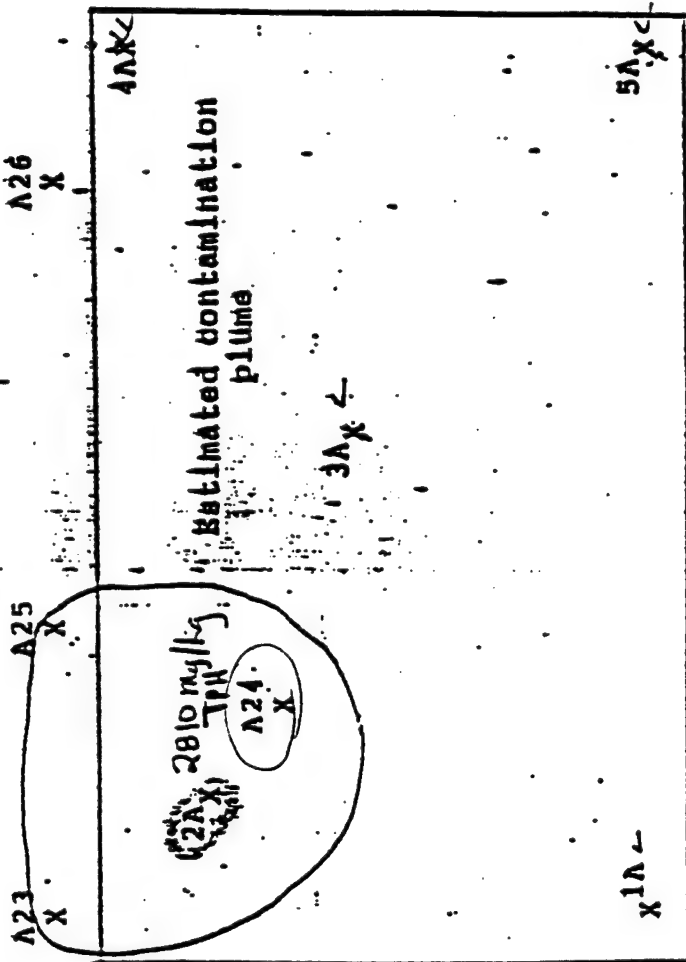
DATE DRILLED 1-18-90

FIGURE 4. REPRESENTATIVE SOIL BORING LOG - UST 173.

Sampling grid for building 272

2A-2810mg/kg
1A, 3A, 4A, 5A - <10mg/kg

Bld 272



NOTE: Sample point A24 has obstructions, making sampling below five feet impossible with drill rig. Suggested alternate is backhoe and shovel, if lower depths are required.

NOTE: Sampling in contaminated area (2A) was limited to a depth of 3' due to a large object that resisted core drilling in this entire area.

2A-2810-TPH-3'

A23- 738-TPH-3'

A24- 1090-TPH-5'

FIGURE 5. SOIL SAMPLING LOCATIONS - UST 272



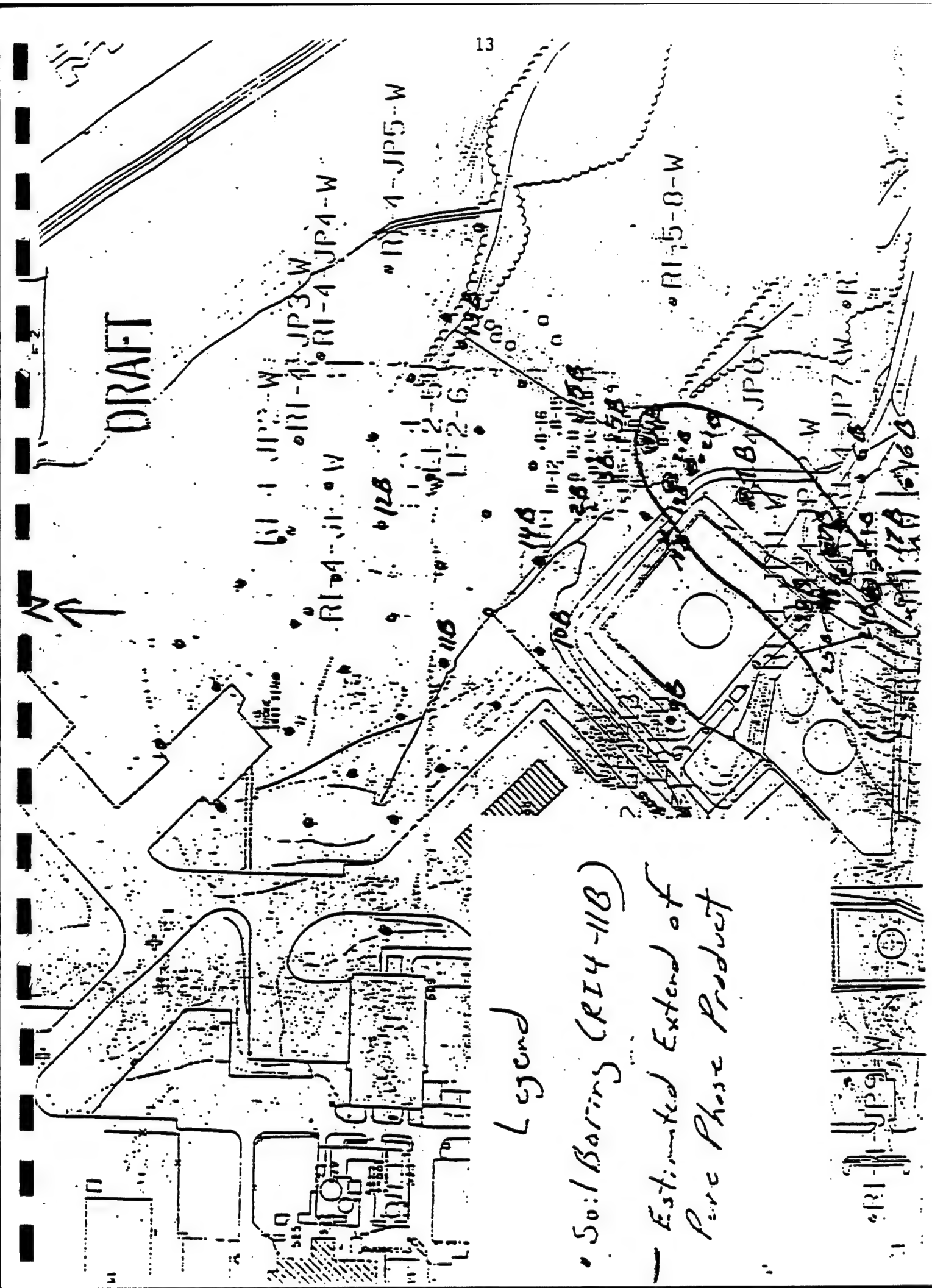


FIGURE 7. ESTIMATED EXTENT OF FREE PRODUCT PLUME - SITE SS10.

The depth and thickness of the subsurface strata indicated on the section (profile) were generalized from and interpolated between test locations. Information on actual subsurface conditions exists only at the specific locations and dates indicated. Subsurface conditions and water levels at other locations may differ from conditions occurring at the indicated locations.

FIGURE 8. GEOLOGIC CROSS-SECTION OF SPILL SITE 8810.

three test sites, if possible). The wells and monitoring points will be installed using a two-man power auger or a portable drill rig to bore down to just above the water table. Three to four soil samples will be collected for chemical/physical analysis.

- The air permeability test will be conducted in the contaminated test location.
- Following the air permeability test, in situ respiration tests will be conducted in both the contaminated and the background test locations.
- Depending on the results of the air permeability test and the in situ respiration test, a decision will be made whether or not to install a blower system in the contaminated area for the long term bioventing test. If the decision is made to install, the blower will be plumbed to the vent well and bioventing will be started (assuming power is available). Site personnel will be trained for blower operation prior to Battelle leaving the site.
- A report detailing the results of the in situ respiration test and the air permeability test will be provided to the project officer and the base POC.

Schedule

Field activities at Robins AFB are planned to begin on August 24, 1992. Battelle will have 2 to 3 people on site for approximately 3 weeks. Site work at SS10 will be conducted during the 3 week period if time allows, otherwise SS10 field work will begin 12/7/92.

Base Support

Robins AFB needs to be able to provide the following:

- Digging permits and utility clearance need to be obtained prior to the initiation of the field work. Underground utilities should be clearly marked to reduce the chance of utility damage or personal injury during soil gas probe and well installation. Battelle will not be able to begin field operations without these clearances.
- Electrical power will need to be easily accessible from the project site. The air permeability test and in situ respiration test can be performed using a gasoline powered electric generator. The operation of the bioventing system will require

Captain Catherine Vogel
Tyndall Air Force Base

16

July 20, 1992

a permanent 220/110 V power source. If power will not be available immediately after the test is completed the bioventing system will be installed for start-up at a later date.

- Regulatory approval, if any is required, will need to be obtained by the base prior to start-up of the bioventing system. The system will likely be configured for air injection so there will be no point source vapor emission from the system. The wells to be installed will not intersect the apparent water table and no groundwater will be pumped.
- The Air Force will need to provide drums to contain soil cuttings and disposal of contaminated soil.
- Base and site clearance will be required for Battelle's site employees. We will furnish you with personal information for each person at least one week prior to starting field operations.

Thank you for your support for this bioremediation research project. If you have any questions please feel free to call me at (614) 424-6122.

Sincerely,

Jeffrey A. Kittel
Researcher
Environmental Technology Department

JAK:sh

APPENDIX B

ANALYTICAL REPORT FOR SITE UST 173 AND SITE SS-10

@ AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 9209004

Work Order Summary

CLIENT: Mr. Jeff Kittel
Battelle
505 King Ave.
Columbus, OH 43201

BILL TO: Accounts Payable
Engineering Science
1700 Broadway Ste. 900
Denver, CO 80290

PHONE: 614-424-6122

FAX: 614-424-3667

DATE RECEIVED: 9/1/92

DATE REPORTED: 9/8/92

INVOICE # 8415

P.O. # DE268.03

AMOUNT: \$565.98

PROJECT # E-S JOB DE268.03

<u>FRACTION #</u>	<u>NAME</u>	<u>TEST</u>	<u>Receipt</u> <u>VAC./Press.</u>	<u>PRICE</u>
01A	R1-V	TO-3	0.5 "Hg	\$120.00
02A	R1-C	TO-3	1.5 "Hg	\$120.00
03A	Ambient -R1	TO-3	0 "Hg	\$120.00
04A	R1-A	TO-3	1.0 "Hg	\$120.00
05A	Lab Blank	TO-3	NA	NC

Misc. Charges	1 Liter SUMMA Canister Preparation (4) @ \$10.00 each.	\$40.00
	Shipping (8/27/92)	\$45.98

REVIEWED BY: [Signature]

DATE: 9/9/92

CERTIFIED BY: [Signature]

DATE: 9/9/92

AIR TOXICS LTD.

SAMPLE NAME: R1-V

ID#: 9209004-01A

EPA Method TO-3
(Aromatic Volatile Organics in Air)**BTXE BY GC/PID**

File Name:		6090305	Date of Collection:		8/30/92
Dil. Factor:		4.1	Date of Analysis:		9/3/92
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)	
Benzene	0.004	0.013	Not Detected	Not Detected	
Toluene	0.004	0.015	0.025	0.092	
Total Xylenes	0.004	0.017	2.2	9.3	
Ethyl Benzene	0.004	0.017	0.31	1.3	

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:		6090305	Date of Collection:		8/30/92
Dil. Factor:		4.1	Date of Analysis:		9/3/92
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)	
TPH*	0.041	0.16	300	1200	

*TPH referenced to Jet Fuel (MW=156)

AIR TOXICS LTD.

SAMPLE NAME: R1-C

ID#: 9209004-02A

EPA Method TO-3
(Aromatic Volatile Organics in Air)**BTXE BY GC/PID**

File Name:		6090306	Date of Collection:		8/30/92
Dil. Factor:		2.1	Date of Analysis:		9/3/92
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)	
Benzene	0.002	0.007	Not Detected	Not Detected	
Toluene	0.002	0.007	0.006	0.019	
Total Xylenes	0.002	0.007	0.098	0.31	
Ethyl Benzene	0.002	0.007	0.14	0.44	

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:		6090306	Date of Collection:		8/30/92
Dil. Factor:		2.1	Date of Analysis:		9/3/92
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)	
TPH*	0.021	0.084	27	110	

*TPH referenced to Jet Fuel (MW=156)

AIR TOXICS LTD.

SAMPLE NAME: Ambient -R1

ID#: 9209004-03A

EPA Method TO-3
(Aromatic Volatile Organics in Air)**BTXE BY GC/PID**

File Name:		6090308	Date of Collection:		8/30/92
Dil. Factor:		2.0	Date of Analysis:		9/3/92
	MDL	MDL	Amount	Amount	
Compound	(ppmv)	(uG/L)	(ppmv)	(uG/L)	
Benzene	0.002	0.006	Not Detected	Not Detected	
Toluene	0.002	0.007	Not Detected	Not Detected	
Total Xylenes	0.002	0.008	Not Detected	Not Detected	
Ethyl Benzene	0.002	0.008	Not Detected	Not Detected	

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:		6090308	Date of Collection:		8/30/92
Dil. Factor:		2.0	Date of Analysis:		9/3/92
	MDL	MDL	Amount	Amount	
Compound	(ppmv)	(uG/L)	(ppmv)	(uG/L)	
TPH*	0.020	0.080	0.20	0.80	

*TPH referenced to Jet Fuel (MW=156)

AIR TOXICS LTD.

SAMPLE NAME: R1-A

ID#: 9209004-04A

EPA Method TO-3
(Aromatic Volatile Organics in Air)

BTXE BY GC/PID

File Name:	6090309	Date of Collection:	8/30/92	
Dil. Factor:	2.1	Date of Analysis:	9/3/92	
	MDL	MDL	Amount	Amount
Compound	(ppmv)	(uG/L)	(ppmv)	(uG/L)
Benzene	0.002	0.007	Not Detected	Not Detected
Toluene	0.002	0.008	0.052	0.19
Total Xylenes	0.002	0.009	0.81	3.4
Ethyl Benzene	0.002	0.009	0.055	0.23

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:		6090309		Date of Collection:		8/30/92	
Dil. Factor:		2.1		Date of Analysis:		9/3/92	
		MDL		MDL		Amount	
Compound		(ppmv)		(uG/L)		Amount	
TPH*		0.021		0.084		290	
						1200	

*TPH referenced to Jet Fuel (MW=156)

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 9209004-05A

EPA Method TO-3
(Aromatic Volatile Organics in Air)**BTXE BY GC/PID**

File Name:		6090303	Date of Collection:		NA
Dil. Factor:		1.0	Date of Analysis:		9/3/92
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)	
Benzene	0.001	0.003	Not Detected	Not Detected	
Toluene	0.001	0.004	Not Detected	Not Detected	
Total Xylenes	0.001	0.004	Not Detected	Not Detected	
Ethyl Benzene	0.001	0.004	Not Detected	Not Detected	

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:		6090303	Date of Collection:		NA
Dil. Factor:		1.0	Date of Analysis:		9/3/92
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)	
TPH*	0.010	0.040	Not Detected	Not Detected	

*TPH referenced to Jet Fuel (MW=156)



Columbus Laboratories

CHAIN OF CUSTODY RECORD

Form No.

[illegible]

@ AIR TOXICS LTD.

AN ENVIRONMENTAL ANALYTICAL LABORATORY

WORK ORDER #: 9209019

Work Order Summary

CLIENT: Mr. Jeff Kittel
Battelle
505 King Ave.
Columbus, OH 43201

BILL TO: Accounts Payable
Engineering Science
1700 Broadway Ste. 900
Denver, CO 80290

PHONE: 614-424-6122
FAX: 614-424-3667

INVOICE # 8436**P.O. #****DATE RECEIVED:** 9/4/92**AMOUNT:** \$520.00**DATE REPORTED:** 9/14/92**PROJECT #** DE268.03

<u>FRACTION #</u>	<u>NAME</u>	<u>TEST</u>	<u>Receipt</u> <u>VAC./Press.</u>	<u>PRICE</u>
01A	Ambient	TO-3	1.5 "Hg	\$120.00
02A	R2-C-8	TO-3	0.5 "Hg	\$120.00
03A	R2-A-5'	TO-3	0 "Hg	\$120.00
04A	R2-VW	TO-3	0.5 "Hg	\$120.00

Misc. Charges 1 Liter SUMMA Canister Preparation (4) @ \$10.00 each. \$40.00

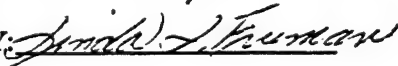
REVIEWED BY:



DATE:

9/15/92

CERTIFIED BY:



DATE:

9/15/92

11325 SUNRISE GOLD CIRCLE, SUITE E • RANCHO CORDOVA, CA 95742

(916) 638-9892 • FAX (916) 638-9917

AIR TOXICS LTD.

SAMPLE NAME: Ambient

ID#: 9209019-01A

EPA Method TO-3
(Aromatic Volatile Organics in Air)**BTXE BY GC/PID**

File Name:		6090809	Date of Collection: 9/3/92	
Dil. Factor:		2.1	Date of Analysis: 9/8/92	
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.002	0.007	Not Detected	Not Detected
Toluene	0.002	0.008	Not Detected	Not Detected
Total Xylenes	0.002	0.009	Not Detected	Not Detected
Ethyl Benzene	0.002	0.009	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:		6090809	Date of Collection: 9/3/92	
Dil. Factor:		2.1	Date of Analysis: 9/8/92	
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.021	0.084	0.55	2.2

*TPH referenced to Jet Fuel (MW=156)

AIR TOXICS LTD.

SAMPLE NAME: R2-C-8

ID#: 9209019-02A

EPA Method TO-3
(Aromatic Volatile Organics in Air)**BTXE BY GC/PID**

File Name:		6090810		Date of Collection: 9/3/92	
Dil. Factor:		5200		Date of Analysis: 9/8/92	
	MDL	MDL		Amount	Amount
Compound	(ppmv)	(uG/L)		(ppmv)	(uG/L)
Benzene	5.2	16		330	1000
Toluene	5.2	16		120	370
Total Xylenes	5.2	16		100	310
Ethyl Benzene	5.2	16		22	69

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:		6090810		Date of Collection: 9/3/92	
Dil. Factor:		5200		Date of Analysis: 9/8/92	
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)	
TPH*	52	210	72000	290000	

*TPH referenced to Jet Fuel (MW=156)

AIR TOXICS LTD.

SAMPLE NAME: R2-A-5'

ID#: 9209019-03A

EPA Method TO-3

(Aromatic Volatile Organics in Air)

BTXE BY GC/PID

File Name:		6090811	Date of Collection: 9/3/92	
Dil. Factor:		10000	Date of Analysis: 9/8/92	
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	10	31	220	690
Toluene	10	37	87	320
Total Xylenes	10	42	72	310
Ethyl Benzene	10	42	14	59

TOTAL PETROLEUM HYDROCARBONS**GC/FID**

(Quantitated as Jet Fuel)

File Name:		6090811	Date of Collection: 9/3/92	
Dil. Factor:		10000	Date of Analysis: 9/8/92	
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	100	400	50000	200000

*TPH referenced to Jet Fuel (MW=156)

AIR TOXICS LTD.

SAMPLE NAME: R2-VW

ID#: 9209019-04A

EPA Method TO-3
(Aromatic Volatile Organics in Air)**BTXE BY GC/PID**

File Name:		6090812	Date of Collection: 9/3/92	
Dil. Factor:		10000	Date of Analysis: 9/8/92	
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	10	31	260	810
Toluene	10	37	120	440
Total Xylenes	10	42	81	340
Ethyl Benzene	10	42	11	47

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:		6090812	Date of Collection: 9/3/92	
Dil. Factor:		10000	Date of Analysis: 9/8/92	
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	100	400	42000	170000

*TPH referenced to Jet Fuel (MW=156)

AIR TOXICS LTD.

SAMPLE NAME: Lab Blank

ID#: 9209019-05A

EPA Method TO-3
(Aromatic Volatile Organics in Air)**BTXE BY GC/PID**

File Name:		6090808	Date of Collection: NA	
Dil. Factor:		1.0	Date of Analysis: 9/8/92	
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
Benzene	0.001	0.003	Not Detected	Not Detected
Toluene	0.001	0.004	Not Detected	Not Detected
Total Xylenes	0.001	0.004	Not Detected	Not Detected
Ethyl Benzene	0.001	0.004	Not Detected	Not Detected

TOTAL PETROLEUM HYDROCARBONS
GC/FID
(Quantitated as Jet Fuel)

File Name:		6090808	Date of Collection: NA	
Dil. Factor:		1.0	Date of Analysis: 9/8/92	
Compound	MDL (ppmv)	MDL (uG/L)	Amount (ppmv)	Amount (uG/L)
TPH*	0.010	0.040	Not Detected	Not Detected

*TPH referenced to Jet Fuel (MW=156)



Form No.

[illegible]

ENGINEERING-SCIENCE, INC.

Report Date: October 9, 1992

Work Order No.: 4294

Client: Jeff Kittel
Battelle
505 King Ave.
Columbus, OH 43201

Date of Sample Receipt: 09/01/92

Your soil samples identified as:

R1-A-8.5'-10

R1-V-4.0'-4.5'

were analyzed for BTEX by EPA Method 8020, pH, alkalinity, iron, total Kjeldahl nitrogen, moisture, TRPH by EPA Method 418.1, soil classification by ASTM D422 and total phosphorus.

In addition your soil sample identified as:

R1-V-18'

was analyzed for pH, alkalinity, iron, total Kjeldahl nitrogen, moisture soil classification by ASTM D422 and total phosphorus.

Finally your soil sample identified as:

R1-V-18.5-19'

was analyzed for BTEX by EPA Method 8020 and TRPH by EPA Method 418.1.

The analytical reports for the samples listed above are attached.

LEGEND FOR INORGANIC RESULT QUALIFIERS

- U The analyte was analyzed for but not detected.
- B Reported value is less than Reporting limit but greater than the IDL.
- N Spiked sample recovery not within control limits.
- S Reported value was determined by the Method of Standard Additions.
- * Duplicate analysis not within control limits.
- W Post digestion spike for Furance AA analysis out of control limits (85-115%), while sample absorbance is less than 50% of spike absorbance
- + Correlation co-efficient for MSA is less than 0.995.
- E The reported value is estimated because of the presence of interference.
- R Quality Control indicates that data are not usable (compound may or may not be present). Re-sampling and re-analysis is necessary for verification.
- M Duplicate injection precision not met.

GC VOLATILES DATA PACKAGE

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.: 4294

% Moisture: 17.5

Client ID: R1-A-8.5'-10'

Matrix: SOIL

Laboratory ID: 4294-1

Level: LOW

Unit: ug/KG


Dilution Factor: 1

Date Analyzed: 09/04/92
Date Confirmed: 09/08/92

Compound	Primary Result	Confirmatory Result	Reportin Limit
Benzene	ND	ND	0.7
Ethyl Benzene	6.3	9.0	0.6
Toluene	2.7	2.0	0.8
Xylenes (total)	89.6	79.0	1.1

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AD

GROUP LEADER: 

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.:4294

% Moisture: 16.2

Client ID:R1-V-4.0'-4.5'

Matrix:SOIL

Laboratory ID:4294-2

Level:MEDIUM

Unit:ug/KG

Dilution Factor: 4


Date Analyzed:09/08/92

Date Confirmed:09/09/92
=====

Compound	Primary Result	Confirmatory Result	Reporting Limit
Benzene	ND	ND	290.0
Ethyl Benzene	330.0	330.0	240.0
Toluene	ND	ND	330.0
Xylenes (total)	1200	3000.0	430.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AM

GROUP LEADER: 

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.:4294

% Moisture: 14.9

Client ID:R1-V-18.5'-19'

Matrix:SOIL

Laboratory ID:4294-4

Level:LOW

Unit:ug/KG

Dilution Factor: 1

Date Analyzed:09/08/92
Date Confirmed:09/04/92

Compound	Primary Result	Confirmatory Result	Reportin Limit
Benzene	ND	ND	0.7
Ethyl Benzene	ND	ND	0.6
Toluene	ND	ND	0.8
Xylenes (total)	1.1	3.7	1.0

ND-Not Detected
NA-Not Applicable
D-Dilution FactorANALYST: *AK*GROUP LEADER: *fu*

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.:4294

% Moisture:NA

Client ID:METHOD BLANK

Matrix:SOIL

Laboratory ID:MSVG5920904

Level:LOW

Unit:ug/KG

Dilution Factor: 1

Date Analyzed:09/04/92
Date Confirmed:

Compound	Primary Result	Confirmatory Result	Reporting Limit
Benzene	ND	ND	0.6
Ethyl Benzene	ND	ND	0.5
Toluene	ND	ND	0.7
Xylenes (total)	ND	ND	0.9

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: MB

GROUP LEADER: 

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.:4294

% Moisture:NA

Client ID:METHOD BLANK

Matrix:SOIL

Laboratory ID:MWVG5920909

Level:MEDIUM

Unit:ug/KG

Dilution Factor: 1

Date Analyzed:09/09/92

Date Confirmed:NA

Compound	Primary Result	Confirmatory Result	Reporting Limit
Benzene	ND	ND	60.0
Ethyl Benzene	ND	ND	50.0
Toluene	ND	ND	70.0
Xylenes (total)	ND	ND	90.0

ND-Not Detected
NA-Not Applicable
D-Dilution FactorANALYST: *ASD*GROUP LEADER: *Reword*

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.:4294

% Moisture:NA

Client ID:METHOD BLANK

Matrix:SOIL

Laboratory ID:MSVG3920908B

Level:LOW

Unit:ug/KG

Dilution Factor: 1

Date Analyzed:09/08/92
Date Confirmed:

Compound	Primary Result	Confirmatory Result	Reporting Limit
Benzene	ND	ND	0.6
Ethyl Benzene	ND	ND	0.5
Toluene	ND	ND	0.7
Xylenes (total)	ND	ND	0.9

ND-Not Detected
NA-Not Applicable
D-Dilution FactorANALYST: *AS*GROUP LEADER: *Robert*

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.:4294

% Moisture:NA

Client ID:METHOD BLANK

Matrix:SOIL

Laboratory ID:MWVG3920908B

Level:MEDIUM

Unit:ug/KG

Dilution Factor: 1

Date Analyzed:09/08/92
Date Confirmed:NA-----

Compound	Primary Result	Confirmatory Result	Reporting Limit

Benzene	ND	ND	60.0
Ethyl Benzene	ND	ND	50.0
Toluene	ND	ND	70.0
Xylenes (total)	ND	ND	90.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB

GROUP LEADER: 

METHOD BLANK SUMMARY

WO # 4294

LAB NAME : ENGINEERING-SCIENCE, INC.

DATE ANALYZED : 09/08/92

LAB SAMPLE ID: MWVG3920908B

DATE EXTRACTED : NA

MATRIX : MEDIUM SOIL

INSTRUMENT ID: VGC-3

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE ANALYZED
MWVG3920908B	METHOD BLANK	09/08/92
4294-2	R1-V-4.0-4.5'	09/08/92

METHOD BLANK SUMMARY

WO # 4294

LAB NAME : ENGINEERING-SCIENCE, INC.

DATE ANALYZED : 09/09/92

LAB SAMPLE ID: MWVG5920909

DATE EXTRACTED : NA

MATRIX : MEDIUM SOIL

INSTRUMENT ID: VGC-5

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE ANALYZED
MWVG5920909	METHOD BLANK	09/09/92
4294-2	R1-V-4.0-4.5'	09/09/92

METHOD BLANK SUMMARY

WO # 4294

LAB NAME : ENGINEERING-SCIENCE, INC.

DATE ANALYZED : 09/04/92

LAB SAMPLE ID:MSVG5920904

DATE EXTRACTED : NA

MATRIX :SOIL

INSTRUMENT ID:VGC-5

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE ANALYZED
MSVG5920904	METHOD BLANK	09/04/92
SSVG5920904A	SPIKE	09/04/92
SSVG5920904B	SPIKE DUP	09/04/92
4294-1	R1-A-8.5'-10'	09/04/92
4294-4	R1-V-18.5'-19'	09/04/92

METHOD BLANK SUMMARY

WO # 4294

LAB NAME : ENGINEERING-SCIENCE, INC.

DATE ANALYZED : 09/08/92

LAB SAMPLE ID:MSVG3920908B

DATE EXTRACTED : NA

MATRIX :SOIL

INSTRUMENT ID:VGC-3

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE ANALYZED
MSVG3920908B	METHOD BLANK	09/08/92
4294-1	R1-A-8.5'-10'	09/08/92
4292-4	R1-V-18.5'-19'	09/08/92

ES-ENGINEERING SCIENCE, INC.

600 BANCROFT WAY
BERKELEY, CA 94710

GC ANALYTICAL REPORT
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

MATRIX: MEDIUM SOIL

COLUMN ID: VGC-5 DB624

DATE: 09/09/92

LABORATORY NO.

CLIENT ID

a-a-a-TriFluoro
Toluene

MWVG5920909
4294-2

METHOD BLANK
R1-V-4.0'-4.5'

97
62

ES-ENGINEERING SCIENCE, INC.

600 BANCROFT WAY
BERKELEY, CA 94710

GC ANALYTICAL REPORT
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

MATRIX: MEDIUM SOIL

COLUMN ID: VGC-3 VOCOL

DATE: 09/08/92

LABORATORY NO.

CLIENT ID

a-a-a-TriFluoro
Toluene

MWVG3920908B
4294-2

METHOD BLANK
R1-V-4.0'-4.5'

118
52

ES-ENGINEERING SCIENCE, INC.

600 BANCROFT WAY
BERKELEY, CA 94710

GC ANALYTICAL REPORT
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

MATRIX: SOIL

COLUMN ID: VGC-3 VOCOL

DATE: 09/08/92

LABORATORY NO.

CLIENT ID

a-a-a-TriFluoro
Toluene

MSVG3920908B

4294-1

4294-4

METHOD BLANK

R1-A-8.5'-10'

R1-V-18.5'-19'

110

77

97

ES-ENGINEERING SCIENCE, INC.

600 BANCROFT WAY
BERKELEY, CA 94710

GC ANALYTICAL REPORT
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

MATRIX: SOIL

COLUMN ID: VGC-5 DB624

DATE: 09/04/92

LABORATORY NO.

CLIENT ID

a-a-a-TriFluoro
Toluene

MSVG5920904
SSVG5920904A
SSVG5920904B
4294-1
4294-4

METHOD BLANK
SPIKE
SPIKE DUP
R1-A-8.5'-10'
R1-V-18.5'-19'

99
105
101
73
88

**TOTAL RECOVERABLE PETROLEUM HYDROCARBONS
DATA PACKAGE**

ES-ENGINEERING SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

=====

ORGANIC ANALYTICAL REPORT

Work Order NO.: 4294

Matrix: Soil

Parameter: TPH

Unit: mg/Kg

Analytical

Method: 418.1

Date Extracted: 09/15/92

QC Batch NO.: S92QCB023TPH

Date Analyzed: 09/22/92

=====

Sample ID:	Client ID:	Result	Reporting Limit	Percent Moisture
4294-01	R1-A-8.5'-10'	5700	5	17.5
4294-02	R1-V-4.0'-4.5'	37	5	16.2
4294-04	R1-V-18.5'-19'	8	5	14.9
MSTPH920915	METHOD BLANK	ND	4	NA

=====

NA_ Not Analyzed
ND_ Not Detected

ANALYST:

Alan J.

GROUP LEADER:

Lucas

ES-ENGINEERING SCIENCE, INC.

600 Bancroft Way
Berkeley. CA 94710

=====

ORGANIC QUALITY CONTROL RESULTS SUMMARY
Blank Spike/Spike Duplicate

Work Order NO.: 4294

QC Sample NO.: SSTPH920915A & B

Analytical Method: 418.1

Blank I.D.: MSTPH920915

Matrix: Soil

QC Batch NO.: S92QCB023TPH

Unit: mg/Kg

=====

Parameter	Date Analyzed	BR	SA	BS	PR	BSD	PR	RPD
TPH	09/22/92	0	165	176	107	172	104	2

=====

BS-Blank Spike
BSD-Blank Spike Duplicate
SA-Spike Added
BR_Blank Result
NA-Not Applicable
NC-Not Calculated
ND-Not Detected

$$RPD = ((BS - BSD) / ((BS + BSD) / 2)) * 100$$

$$PR = ((BS \text{ OR } BSD - BR) / SA) * 100$$

ANALYST:

_____ *Alan J* _____

QUALITY CONTROL:

_____ *MMB* _____

INORGANICS DATA PACKAGE

INORGANICS ANALYTICAL REPORT

Client: ES-Denver
Project: AFCEEWork Order: 4294
Matrix: SolidClient's ID: R1-A R1-V R1-V
-8.5'-10' -4.0'-4.5' -18'

Sample Date: 08/27/92 08/26/92 08/26/92

% Moisture:

Lab ID: 4294.01 4294.02 4292.03

Parameter	-----Results-----	Method	Normal Report Limit	Units	Date Analyzed
Alkalinity	ND ND ND	SM 403(M)	50	mg/Kg CaCO3	09/10/92
Moisture	17.5 16.2 9.1	ASTM D2216	.1	% by wt	09/04/92
pH	5.2 4.9 5.4	EPA 9045	NA	pH Units	09/15/92

Note: Samples for alkalinity analysis were extracted using 10mL water for each 1g sample. These water extracts were analyzed for alkalinity, and the results were calculated in the solid on a dry-weight basis.

NA- Not Applicable

ND- Not Detected

ANALYST: Don AlstonGROUP LEADER: William J. Long

INORGANICS ANALYTICAL REPORT

Client: ES-Denver
Project: AFCEEWork Order: 4294
Matrix: SolidClient's ID: Prep
Blank

Sample Date:

% Moisture:

Lab ID: Prep Blank

Parameter	-----Results-----	Method	Normal Report Limit	Units	Date Analyzed
Alkalinity	ND	SM 403(M)	50	mg/Kg CaCO3	09/10/92
Moisture	NA	ASTM D2216	.1	% by wt	09/04/92
pH	NA	EPA 9045	NA	pH Units	09/15/92

Note: Samples for alkalinity analysis were extracted using 10mL water for each 1g sample. These water extracts were analyzed for alkalinity, and the results were calculated in the solid on a dry-weight basis.

NA- Not Applicable

ND- Not Detected

ANALYST: Don DeatonGROUP LEADER: Will Long

INORGANICS QC SUMMARY - LAB CONTROL SAMPLE

Work Order: 4294 % Moisture: NA
Lab ID of LCS: Matrix: Solid
Alkalinity: 452.22 LCS
Units: mg/Kg CaCO3

Parameter	Date Analyzed LCS	LCS Result	Conc Added	% Rec LCS	Advisory Limits	
					-- % Rec -- Low	High
Alkalinity	09/10/92	23000.00	23650.00	97	80	120

ANALYST: Don MeatonDate 9/29/92REVIEWER: NWBDate 9/29/92

File: M1QCLCSW

INORGANIC QC SUMMARY - MS and MSD

Work Order: 4294

% Moisture: NA

	Alkalinity	Moisture	pH
Lab ID Spk/Dup:	Blank Spk	4286.01	4294.01
QC Batch:	452.22	451.51	453.34

Matrix: Solid

Units: mg/Kg CaCO₃ (Alk)
% by wt. (Mois)
pH Units (pH)

Parameter	Date Analyzed MS/Dup	-----Results-----			RPD	RPD QC Limit	-Conc Added-		Percent Recovered	
		Unspiked Sample	MS/Sample	MSD/Dup			MS	MSD	MS	MSD
Alkalinity	09/10/92	0.00	23000.00	23000.00	0	20	23650.00	23650.00	97	97
Moisture	09/04/92		15.34	18.00	16	20				
pH	09/15/92		5.21	5.49	5	20				

* or N = Outside QC Limit:

QC Limits for % Rec: 75 - 125

ANALYST: Don Gleason
File: M1QCNSWMDate 9/28/92REVIEWER: MWBDate MWB

METALS DATA PACKAGE

METALS CASE NARRATIVE
WORK ORDER NO.4294
SOILS

The concentration of iron in sample MPA-18 was greater than four times the spike added to the MS and MSD samples. The LCS and duplicate LCS results for iron were checked, and the laboratory was found to be in control. All iron results in this batch are therefore reported unqualified based on matrix spike recovery.

The serial dilution sample result for iron did not agree with the undiluted result within 10%, and the diluted sample result was greater than ten times the iron MDL. All iron results in this batch are therefore flagged with "E".

Client ID's were abridged by the laboratory to facilitate computer entry of analytical data. The following should be used as a reference:

CLIENT ID

R1-A-8.5'-10'
R1-V-4.0'-4.5'
R1-V-18'

ABRIDGED ID

A-8.5'
V-4.0'
V-18'

CLIENT SAMPLE ID

A-8.5'

ib Code: ESBL Case No.: 4294S SAS No.: _____ SDG No.: A-3_____

Level (low/med): LOW Date Sampled : 08/27/92

Solids: 82.5

Concentration Units (ug/L or mg/kg dry weight): MG/KG

[illegible]

omments:

V-4.0'

CLIENT SAMPLE ID

V-18'

b Code: ESBL Case No.: 4294S SAS No.: SDG No.: A-3

Lab Sample ID: 4294.03_____

Date Sampled : 08/26/92

Concentration Units (ug/L or mg/kg dry weight): MG/KG

[illegible]

Comments:

INORGANIC ANALYSES DATA SHEET

PBLANK

Concentration Units (ug/L or mg/kg dry weight): MG/KG

[illegible]

Comments:

CLIENT SAMPLE ID

MPA-1851

Contract: AFCEE

SAS No.:

SDG No.: A-3

Level (low/med): LOW

Solids for Sample: 94.7

Concentration Units (ug/L or mg/kg dry weight):MG/KG

[illegible]

Comments:

MPA-1852

Contract: AFCEE

SDG No. : A-3

Level (low/med): LOW

Concentration Units (ug/L or mg/kg dry weight):MG/KG

Comments:

CLIENT SAMPLE ID

MPA-18SD

Concentration Units (ug/L or mg/kg dry weight):MG/KG

[illegible]

BLANK SPIKE SAMPLE

Aqueous LCS Source: _____

3 / 90

BLANK SPIKE SAMPLE

Contract: AFCEE_____

SDG No.: A-3

Aqueous LCS Source: _____

[illegible]

CLIENT SAMPLE ID

LCSSD

Concentration Units (ug/L or mg/kg as received):MG/KG

[illegible]

EPA SAMPLE NO.

MPA-18L

Matrix (soil/water): SOIL_ Level (low/med): LOW__

[illegible]

[illegible]

ILMO2.

ILMO2.1

Engineering Science - Berkeley Laboratory
Inorganics Report

ANALYSIS RUN LOG

Lab Name: E_S__BERKELEY_LABORATORY__

Contract: AFCEE__

Lab Code: ESBL__ Case No.: 4294S__

SAS No.: _____ SDG No.: A-3__

Instrument ID Number: TJA 61 M__

Method: P__

Start Date: 09/17/92

End Date: 09/17/92

EPA Sample No.	D/F	Time	% R	Analytes																	
				F																	
STD1	1.00	1423		X																	
STD2	1.00	1427		X																	
STD3	1.00	1432		X																	
STD4	1.00	1437		X																	
ICV	1.00	1441		X																	
ICB	1.00	1446		X																	
ICSA	1.00	1451		X																	
ICSAB	1.00	1455		X																	
CRI	1.00	1500																			
PBLANK	1.00	1504		X																	
ZZZZZZ	1.00	1509																			
LCSS	1.00	1514		X																	
LCSSD	1.00	1518		X																	
A-8.5'	1.00	1523		X																	
V-4.0'	1.00	1527		X																	
V-18'	1.00	1532		X																	
CCV	1.00	1537		X																	
CCB	1.00	1541		X																	
V-7'3"	1.00	1546		X																	
A-5	1.00	1551		X																	
A-3	1.00	1555		X																	
VW-8	1.00	1600		X																	
MPA-07	1.00	1604		X																	
MPA-18	1.00	1609		X																	
MPA-18S1	1.00	1614		X																	
MPA-18S2	1.00	1618		X																	
MPA-18L	1.00	1623		X																	
CCV	1.00	1627		X																	
CCB	1.00	1632		X																	
MPB-18	1.00	1637		X																	
MPB-06	1.00	1641		X																	
MPC-06	1.00	1646		X																	

ANALYSIS RUN LOG

Contract: AFCEE_____

SAS No.: _____ SDG No.: A-3_____

Method: P_

End Date: 09/17/92

[illegible]

TOTAL KJELDAHL NITROGEN
TOTAL PHOSPHATE
SOIL CLASSIFICATION
DATA PACKAGE



SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4294
Sample Descript: Soil
Analysis for: Total Kjeldahl Nitrogen
First Sample #: 209-0160

Sampled: 8/26-27/92
Received: Sep 2, 1992
Analyzed: Sep 3, 1992
Reported: Sep 21, 1992

LABORATORY ANALYSIS FOR: Total Kjeldahl Nitrogen

Sample Number	Sample Description	Detection Limit mg/kg	Sample Result mg/kg
209-0160	R1-A-8.5'-10'	20	68
209-0161	R1-V-4.0'-4.5'	20	110
209-0162	R1-V-18'	20	92
-	Method Blank	20	N.D.

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL


Tod Granicher
Project Manager

Please Note:

Analysis results reported on a dry-weight basis.

2090160.ENG <5>



SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4294
Sample Descript: Soil
Analysis for: Total Phosphorous
First Sample #: 209-0160

Sampled: 8/26-27/92
Received: Sep 2, 1992
Analyzed: Sep 16, 1992
Reported: Sep 21, 1992

LABORATORY ANALYSIS FOR: Total Phosphorous

Sample Number	Sample Description	Detection Limit mg/kg	Sample Result mg/kg
209-0160	R1-A-8.5'-10'	10	79
209-0161	R1-V-4.0'-4.5'	10	110
209-0162	R1-V-18'	10	64
-	Method Blank	10	N.D.

THIS REPORT HAS BEEN
APPROVED AND REVIEWED BY

Samson 9/28/92
ESBL PROJECT MANAGER DATE

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL

Tod Granicher
Tod Granicher
Project Manager

Please Note:

Analysis results reported on a dry-weight basis.

2090160.ENG <4>



SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4294

QC Sample Group: 209-0160-62

Reported: Sep 21, 1992

QUALITY CONTROL DATA REPORT

ANALYTE	Total Kjeldahl	
	Nitrogen	Total Phosphorous

Method:	EPA351.4	EPA365.3
Analyst:	G. Kern	K. Follett
Reporting Units:	mg/kg	mg/kg
Date Analyzed:	Sep 3, 1992	Jul 16, 1992
QC Sample #:	209-0162	209-0841

Sample Conc.:	84	40
---------------	----	----

Spike Conc. Added:	4000	100
-----------------------	------	-----

Conc. Matrix Spike:	4600	120
------------------------	------	-----

Matrix Spike % Recovery:	113	80
-----------------------------	-----	----

Conc. Matrix Spike Dup.:	4600	130
-----------------------------	------	-----

Matrix Spike Duplicate % Recovery:	113	90
--	-----	----

Relative % Difference:	0.0	8.0
---------------------------	-----	-----

SEQUOIA ANALYTICAL


Tod Granicher
Project Manager

% Recovery:	$\frac{\text{Conc. of M.S.} - \text{Conc. of Sample}}{\text{Spike Conc. Added}} \times 100$
Relative % Difference:	$\frac{\text{Conc. of M.S.} - \text{Conc. of M.S.D.}}{(\text{Conc. of M.S.} + \text{Conc. of M.S.D.}) / 2} \times 100$

2090160.ENG <6>



SEQUOIA ANALYTICAL

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(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4294
Sample Descript: Soil, R1-A-8.5'-10'
Method of Analysis: ASTM D422-63
Lab Number: 209-0160

Sampled: Aug 27, 1992
Received: Sep 2, 1992
Analyzed: Sep 9, 1992
Reported: Sep 21, 1992

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

- (A) TOTAL WEIGHT OF SAMPLE:
(B) WEIGHT RETAINED IN NO. 10 SIEVE:
(C) % PASSING NO. 10 SIEVE:

229.98g
0.75g
99.67

SIEVE TEST FOR
WEIGHT RETAINED
IN NO. 10 SIEVE

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½in.	0.0	0.0	0.0	100
3/8in.	0.0	0.0	0.0	100
No. 4	0.0	0.0	0.0	100
No. 10	0.75g	0.33	0.33	99.67
PAN	0.0			
TOTAL	0.75g			

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	21	22	18	13.3	0.035	28
5	21	20	16	13.7	0.022	25
10	21	19	15	13.8	0.016	23
15	21	18	14	14.0	0.013	22
25	21	18	14	14.0	0.010	22
40	21	18	14	14.0	0.0080	22
60	21	17	13	14.2	0.0067	20
90	21	17	13	14.2	0.0054	20
120	21	17	13	14.2	0.0046	20
1440	21	16	12	14.3	0.0013	19

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):
HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):
SPECIFIC GRAVITY (ASSUMED):
DISPERSING AGENT CORRECTION FACTOR (E):
MENISCUS CORRECTION FACTOR (F):
TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):

65g
0.988
2.65
3
1
0.01348

FORMULAS:
 $R = H - E - F$
 $S = K [\text{SQRT} (L / T)]$
 $P = (R / W) 100$
 $W = (J \cdot 100) / C$
 $J = D \cdot G$

SEQUOIA ANALYTICAL


 Tod Granicher
 Project Manager

2090160.ENG <1>



SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4294
Sample Descript: Soil, R1-V-4.0'-4.5'
Method of Analysis: ASTM D422-63
Lab Number: 209-0161

Sampled: Aug 26, 1992
Received: Sep 2, 1992
Analyzed: Sep 9, 1992
Reported: Sep 21, 1992

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

- (A) TOTAL WEIGHT OF SAMPLE:
- (B) WEIGHT RETAINED IN NO. 10 SIEVE:
- (C) % PASSING NO. 10 SIEVE:

155.43g
0.50g
99.68

SIEVE TEST FOR
WEIGHT RETAINED
IN NO. 10 SIEVE

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½in.	0.0	0.0	0.0	100
3/8in.	0.0	0.0	0.0	100
No. 4	0.0	0.0	0.0	100
No. 10	0.50	0.32	0.32	99.68
PAN	0.0			
TOTAL	0.50			

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	21	29	25	12.2	0.033	38
5	21	28	25	12.4	0.021	37
10	21	27	23	12.5	0.015	35
15	21	27	23	12.5	0.012	35
25	21	27	23	12.5	0.0095	35
40	21	26	22	12.7	0.0076	34
60	21	26	22	12.7	0.0062	34
90	21	25	21	12.9	0.0051	32
120	21	24	20	13.0	0.0044	31
1440	21	24	20	13.0	0.0013	31

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):
 HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):
 SPECIFIC GRAVITY (ASSUMED):
 DISPERSING AGENT CORRECTION FACTOR (E):
 MENISCUS CORRECTION FACTOR (F):
 TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):

65g
0.996
2.65
3
1
0.01348

FORMULAS:

$R = H - E - F$
 $S = K [\text{SQRT} (L / T)]$
 $P = (R / W) 100$
 $W = (J \cdot 100) / C$
 $J = D \cdot G$

SEQUOIA ANALYTICAL

Tod Granicher
Project Manager



SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4294
Sample Descript: Soil, R1-V-18'
Method of Analysis: ASTM D422-63
Lab Number: 209-0162

Sampled: Aug 26, 1992
Received: Sep 2, 1992
Analyzed: Sep 9, 1992
Reported: Sep 21, 1992

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

- (A) TOTAL WEIGHT OF SAMPLE:
- (B) WEIGHT RETAINED IN NO. 10 SIEVE:
- (C) % PASSING NO. 10 SIEVE:

185.38g
38.93g
79.00

SIEVE TEST FOR
WEIGHT RETAINED
IN NO. 10 SIEVE

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½in.	0.0	0.0	0.0	100
3/8in.	0.0	0.0	0.0	100
No. 4	5.49	2.96	2.96	97.04
No. 10	33.44	18.04	21.00	79.00
PAN	0.0			
TOTAL	38.93			

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	21	22	18	13.3	0.035	28
5	21	20	16	13.7	0.022	25
10	21	19	15	13.8	0.016	23
15	21	19	15	13.8	0.013	22
25	21	19	15	13.8	0.010	22
40	21	18	14	14.0	0.0080	22
60	21	18	14	14.0	0.0065	20
90	21	18	14	14.0	0.0053	20
120	21	17	13	14.2	0.0046	20
1440	21	17	13	14.2	0.0013	19

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):
 HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):
 SPECIFIC GRAVITY (ASSUMED):
 DISPERSING AGENT CORRECTION FACTOR (E):
 MENISCUS CORRECTION FACTOR (F):
 TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):

65g
0.991
2.65
3
1
0.01348

FORMULAS:

$R = H - E - F$
 $S = K [\text{SQRT} (L / T)]$
 $P = (R / W) 100$
 $W = (J \cdot 100) / C$
 $J = D \cdot G$

SEQUOIA ANALYTICAL


 Tod Granicher
 Project Manager

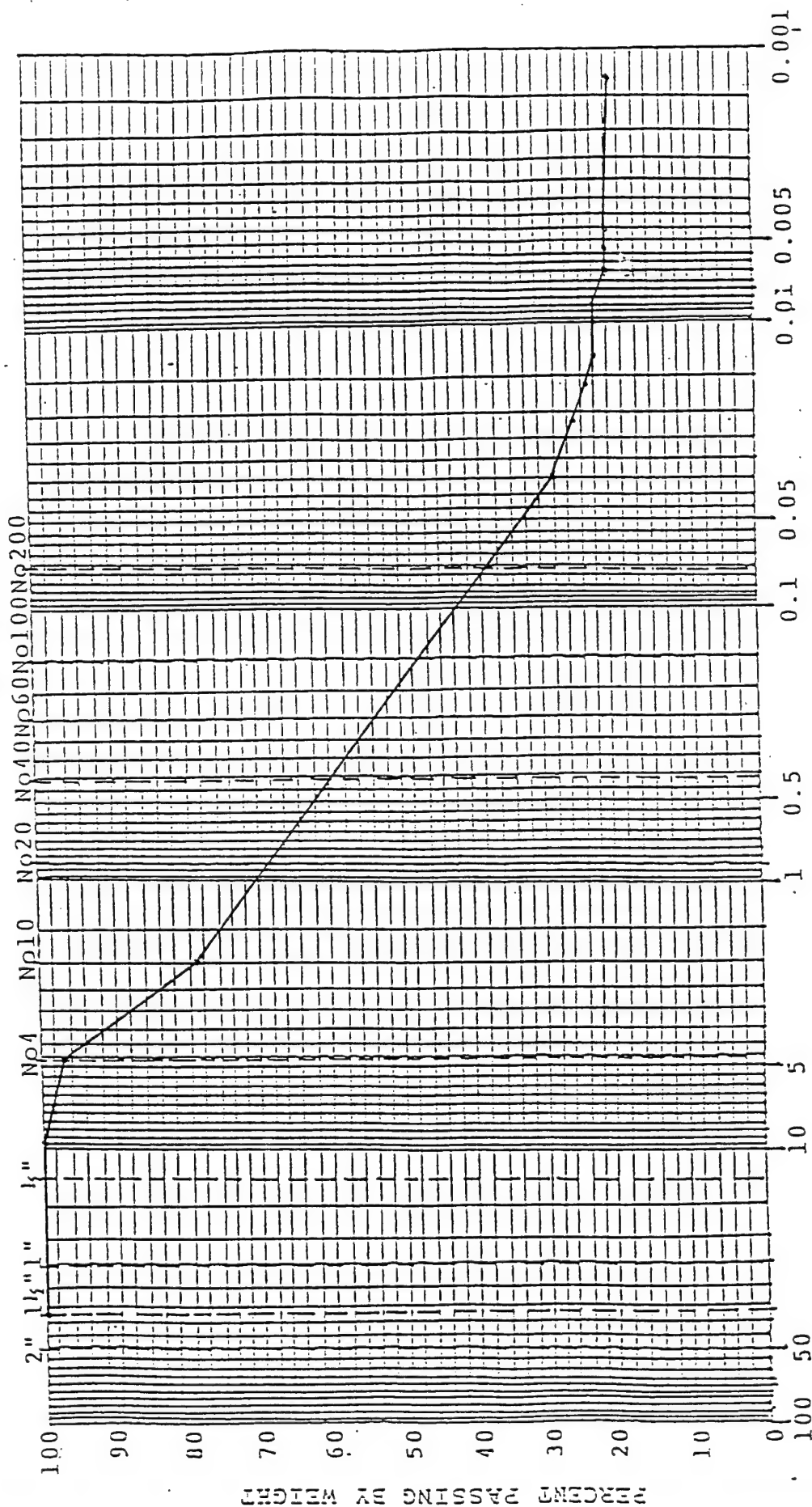
2090160.ENG <3>

SAMPLE DESCRIPTION: Engineering Science, Inc.

LABORATORY NUMBER: 209-0162

U.S. STANDARD SIEVE SIZES

SILT	40%
CLAY	37%
	20%



CHAIN OF CUSTODY RECORD

[illegible]



Form No.

Page of



ENGINEERING-SCIENCE, INC.

BERKELEY LABORATORY
600 BANCROFT WAY
BERKELEY, CA 94710
Tel: (415) 841-7353

Report Date: October 15, 1992

Work Order No.: 4310

Client: Jeff Kittel
Battelle
505 King Ave
Columbus, OH 43201

Date of Sample Receipt: 09/04/92

Your soil samples identified as:

R2-V-7'-3"

R2-A-5-5.5'

R2-A-3-3.5'

were analyzed for BTEX by EPA Method 8020, pH, alkalinity, iron, total kjeldahl nitrogen, soil moisture, TRPH by EPA Method 418.1, soil classification by ASTM D422 and total phosphorus.

The analytical reports for the samples listed above are attached.

GC VOLATILES DATA PACKAGE

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.:4310

% Moisture: 8.18

Client ID:R2-V-7'3"

Matrix:SOIL

Laboratory ID:4310-1

Level:MEDIUM

Unit:ug/KG

Dilution Factor: 20

Date Analyzed:09/09/92

Date Confirmed:09/14/92

Compound	Primary Result	Confirmatory Result	Reportin Limit
Benzene	ND	ND	1300.0
Ethyl Benzene	24000.0	39000.0	1100.0
Toluene	68000.0	59000.0	1500.0
Xylenes (total)	170000.0	220000.0	2000.0

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: *AB*GROUP LEADER: *hew*

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.: 4310

% Moisture: 8.18

Client ID: R2-A-5-5.5'

Matrix: SOIL

Laboratory ID: 4310-2

Level: MEDIUM

Unit: ug/KG

Dilution Factor: 4

Date Analyzed: 09/09/92

Date Confirmed: 09/14/92

Compound	Primary Result	Confirmatory Result	Reporting Limit
Benzene	ND	ND	260.0
Ethyl Benzene	480.0	2000.0	220.0
Toluene	870.0	700.0	300.0
Xylenes (total)	3600.0	6800.0	390.0

ND-Not Detected
NA-Not Applicable
D-Dilution FactorANALYST: *AB*GROUP LEADER: *Robert*

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.:4310

% Moisture: 11.82

Client ID:R2-A-3-3.5'

Matrix:SOIL

Laboratory ID:4310-3

Level:LOW

Unit:ug/KG

Dilution Factor: 5

Date Analyzed:09/10/92
Date Confirmed:09/14/92

Compound	Primary Result	Confirmatory Result	Reporting Limit
Benzene	80.0	53.0	3.4
Ethyl Benzene	83.0	54.0	2.8
Toluene	100.0	98.0	4.0
Xylenes (total)	480.0	540.0	5.1

ND-Not Detected
NA-Not Applicable
D-Dilution FactorANALYST: *AB*GROUP LEADER: *Rumel*

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.:4310

% Moisture:NA

Client ID:METHOD BLANK

Matrix:SOIL

Laboratory ID:MSVG3920910

Level:LOW

Unit:ug/KG

Dilution Factor: 1

Date Analyzed:09/10/92

Date Confirmed:-----

Compound	Primary Result	Confirmatory Result	Reporting Limit
Benzene	ND	ND	0.6
Ethyl Benzene	ND	ND	0.5
Toluene	ND	ND	0.7
Xylenes (total)	ND	ND	0.9

ND-Not Detected
NA-Not Applicable
D-Dilution FactorANALYST: *AS*GROUP LEADER: *[Signature]*

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.:4310

% Moisture:NA

Client ID:METHOD BLANK

Matrix:SOIL

Laboratory ID:MSVG5920914

Level:LOW

Unit:ug/KG

Dilution Factor: 1

Date Analyzed:09/14/92
Date Confirmed:

Compound	Primary Result	Confirmatory Result	Reporting Limit
Benzene	ND	ND	0.6
Ethyl Benzene	ND	ND	0.5
Toluene	ND	ND	0.7
Xylenes (total)	ND	ND	0.9

ND-Not Detected
NA-Not Applicable
D-Dilution Factor

ANALYST: AB

GROUP LEADER: 

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.:4310

% Moisture:NA

Client ID:METHOD BLANK

Matrix:SOIL

Laboratory ID:MWVG3920909

Level:MEDIUM

Unit:ug/KG

Dilution Factor: 1

Date Analyzed:09/09/92
Date Confirmed:-----

Compound	Primary Result	Confirmatory Result	Reporting Limit

Benzene	ND	ND	60.0
Ethyl Benzene	ND	ND	50.0
Toluene	ND	ND	70.0
Xylenes (total)	ND	ND	90.0

ND-Not Detected
NA-Not Applicable
D-Dilution FactorANALYST: *AS*GROUP LEADER: *hmsd*

GC ANALYTICAL REPORT
Analytical Method
8020 Aromatic Compounds

Work Order NO.:4310

% Moisture:NA

Client ID:METHOD BLANK

Matrix:SOIL

Laboratory ID:MWVG2920914

Level:MEDIUM

Unit:ug/KG

Dilution Factor: 1

Date Analyzed:09/14/92
Date Confirmed:

Compound	Primary Result	Confirmatory Result	Reporting Limit
Benzene	ND	ND	60.0
Ethyl Benzene	ND	ND	50.0
Toluene	ND	ND	70.0
Xylenes (total)	ND	ND	90.0

ND-Not Detected
NA-Not Applicable
D-Dilution FactorANALYST: *AS*GROUP LEADER: *Luoni*

ES-ENGINEERING SCIENCE, INC.

600 BANCROFT WAY
BERKELEY, CA 94710

GC ANALYTICAL REPORT
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

MATRIX: LOW SOIL

COLUMN ID: VGC-3 VOCOL

DATE: 09/10/92

LABORATORY NO.

CLIENT ID

a-a-a-TriFluoro
Toluene

MSVG3920910
SSVG3920910A
SSVG3920910B
4310-3

METHOD BLANK
SPIKE
SPIKE DUP
R2-A-3-3.5'

111
110
102
94

ES-ENGINEERING SCIENCE, INC.

600 BANCROFT WAY
BERKELEY, CA 94710

GC ANALYTICAL REPORT
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

MATRIX: LOW SOIL

COLUMN ID: VGC-5 DB624

DATE: 09/14/92

LABORATORY NO.

CLIENT ID

a-a-a-TriFluoro
Toluene

MSVG5920914
SSVG5920914A
SSVG5920914B
4310-3

METHOD BLANK
SPIKE
SPIKE DUP
R2-A-3-3.5'

92
91
92
144

ES-ENGINEERING SCIENCE, INC.

600 BANCROFT WAY
BERKELEY, CA 94710

GC ANALYTICAL REPORT
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

MATRIX: MEDIUM SOIL

COLUMN ID: VGC-3 VOCOL

DATE: 09/09/92

LABORATORY NO.

CLIENT ID

a-a-a-TriFluoro
Toluene

MWVG3920909	METHOD BLANK	78
SWVG3920909A	SPIKE	98
SWVG3920909B	SPIKE DUP	99
4310-1	R2-V-7'3"	71
4310-2	R2-A-5-5.5'	98

ES-ENGINEERING SCIENCE, INC.

600 BANCROFT WAY
BERKELEY, CA 94710

GC ANALYTICAL REPORT
ANALYTICAL REPORT
BTEX AROMATIC COMPOUNDS

MATRIX: MEDIUM SOIL

COLUMN ID: VGC-2 DB624

DATE: 09/14/92

LABORATORY NO.

CLIENT ID

a-a-a-TriFluoro
Toluene

MWVG2920914
4310-1
4310-2

METHOD BLANK
R2-V-7'3"
R2-A-5-5.5'

98
140
118

METHOD BLANK SUMMARY

WO # 4210³

LAB NAME : ENGINEERING-SCIENCE, INC.

DATE ANALYZED : 09/10/92

LAB SAMPLE ID:MSVG3920910

DATE EXTRACTED : NA

MATRIX :SOIL

INSTRUMENT ID:VGC-3

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE ANALYZED
-----	-----	-----
MSVG3920910	METHOD BLANK	09/10/92
SSVG3920910A	SPIKE	09/10/92
SSVG3920910B	SPIKE DUPLICATE	09/10/92
4310-3	R2-A-3-3.5'	09/10/92

METHOD BLANK SUMMARY

WO # 4310

LAB NAME : ENGINEERING-SCIENCE, INC.

DATE ANALYZED : 09/14/92

LAB SAMPLE ID:MSVG5920914

DATE EXTRACTED : NA

MATRIX :SOIL

INSTRUMENT ID:VGC-5

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE ANALYZED
MSVG5920914	METHOD BLANK	09/14/92
SSVG5920914A	SPIKE	09/14/92
SSVG5920914B	SPIKE DUPLICATE	09/14/92
4310-3	R2-A-3-3.5'	09/14/92

METHOD BLANK SUMMARY

WO # 4310

LAB NAME : ENGINEERING-SCIENCE, INC.

DATE ANALYZED : 09/10/92 ^{09 TP 10/15}

LAB SAMPLE ID: MWVG3920909

DATE EXTRACTED : NA

MATRIX : MEDIUM SOIL

INSTRUMENT ID: VGC-3

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE ANALYZED
MWVG3920909	METHOD BLANK	09/09/92
SWVG3920909A	SPIKE	09/09/92
SWVG3920909B	SPIKE DUP	09/09/92
4310-1	R2-V-7'3"	09/09/92
4310-2	R2-V-5-5.5'	09/09/92

METHOD BLANK SUMMARY

WO # 4310

LAB NAME : ENGINEERING-SCIENCE, INC.

DATE ANALYZED : 09/14/92

LAB SAMPLE ID: MWVG2920914

DATE EXTRACTED : NA

MATRIX : MEDIUM SOIL

INSTRUMENT ID: VGC-2

LAB SAMPLE ID	CLIENT SAMPLE ID	DATE ANALYZED
MWVG2920914	METHOD BLANK	09/14/92
4310-1	R2-V-7'-3"	09/14/92
4310-2	R2-A-5-5.5'	09/14/92

**TOTAL RECOVERABLE PETROLEUM HYDROCARBONS
DATA PACKAGE**

ES-ENGINEERING SCIENCE, INC.

600 Bancroft Way
Berkeley, CA 94710

ORGANIC ANALYTICAL REPORT

Work Order NO.: 4310

Matrix: Soil

Parameter: TPH

Unit: mg/Kg

Analytical

Method: 418.1

Date Extracted: 09/22/92

QC Batch NO.: S92QCB023TPH

Date Analyzed: 09/22/92

Sample ID:	Client ID:	Result	Reporting Limit	Percent Moisture
4310-01	R2-V-7'3"	9000	4	8.2
4310-02	R2-A-5-5.5'	58	5	11.8
4310-03	R2-A-3-3.5'	150	4	9.8
MSTPH920922	METHOD BLANK	ND	4	NA

NA_ Not Analyzed
ND_ Not Detected

ANALYST:



GROUP LEADER:



ES-ENGINEERING SCIENCE, INC.

600 Bancroft Way
Berkeley. CA 94710

ORGANIC QUALITY CONTROL RESULTS SUMMARY
Blank Spike/Spike Duplicate

Work Order NO.: 4310

QC Sample NO.: SSTPH920915A & B

Analytical Method: 418.1

Blank I.D.: MSTPH920915

Matrix: Soil

QC Batch NO.: S92QCB023TPH

Unit: mg/Kg

Parameter Date
 Analyzed BR SA BS PR BSD PR RPD

TPH 09/22/92 0 165 176 107 172 104 2

BS-Blank Spike
BSD-Blank Spike Duplicate
SA-Spike Added
BR_Blank Result
NA-Not Applicable
NC-Not Calculated
ND-Not Detected

$$RPD = ((BS - BSD) / ((BS + BSD) / 2)) * 100$$

$$PR = ((BS \text{ OR } BSD - BR) / SA) * 100$$

ANALYST:

Alan J

QUALITY CONTROL:

NWB

INORGANICS DATA PACKAGE

INORGANICS ANALYTICAL REPORT

Client: ES-Denver
Project: AFCEEWork Order: 4310
Matrix: SolidClient's ID: R2-V R2-A R2-A
-7'3" -5-5.5' -3-3.5'Sample Date: 09/01/92 09/01/92 09/01/92
% Moisture:
Lab ID: 4310.01 4310.02 4310.03

Parameter	-----Results-----	Method	Normal Report Limit	Units	Date Analyzed
Alkalinity	ND ND ND	SM 403(M)	50	mg/Kg CaCO3	09/10/92
Moisture	8.2 11.8 9.8	ASTM D2216	.1	% by wt	09/18/92
pH	5.2 5.0 5.8	EPA 9045	NA	pH Units	09/15/92

Note: Samples for alkalinity analysis were extracted using 10mL water for each 1g sample. These water extracts were analyzed for alkalinity, and the results were calculated in the solid on a dry-weight basis.

NA- Not Applicable
ND- Not Detected

ANALYST:



GROUP LEADER:



INORGANICS ANALYTICAL REPORT

Client: ES-Denver
Project: AFCEEWork Order: 4310
Matrix: SolidClient's ID: Prep
BlankSample Date:
% Moisture:
Lab ID:

Prep Blank

Parameter	-----Results-----	Method	Normal Report Limit	Units	Date Analyzed
Alkalinity	ND	SM 403(M)	50	mg/Kg CaCO3	09/10/92
Moisture	NA	ASTM D2216	.1	% by wt	09/18/92
pH	NA	EPA 9045	NA	pH Units	09/15/92

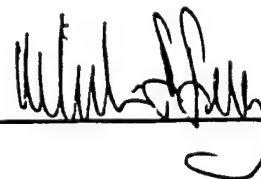
Note: Samples for alkalinity analysis were extracted using 10mL water for each 1g sample. These water extracts were analyzed for alkalinity, and the results were calculated in the solid on a dry-weight basis.

NA- Not Applicable
ND- Not Detected

ANALYST:



GROUP LEADER:



INORGANICS QC SUMMARY - LAB CONTROL SAMPLE

Work Order: 4310 % Moisture: NA
Lab ID of LCS: Matrix: Solid
Alkalinity: 452.22 LCS Units: mg/Kg CaCO3

Parameter	Date Analyzed LCS	LCS Result	Conc Added	% Rec LCS	Advisory Limits	
					-- % Rec -- Low	High
Alkalinity	09/10/92	23000.00	23650.00	97	80	120

ANALYST: Don GleatorDate 9/28/92REVIEWER: NWBDate 9/29/92

File: M1QCLCSW

INORGANIC QC SUMMARY - MS and MSD

Work Order: 4310

% Moisture: NA

Alkalinity Moisture pH
 Lab ID Spk/Dup: Blank Spk 4310.01 4294.01
 QC Batch: 452.22 451.52 453.34

Matrix: Solid

Units: mg/Kg CaCO₃ (Alk)
 % by wt. (Mois)
 pH Units (pH)

Parameter	Date Analyzed MS/Dup	-----Results-----			RPD	RPD QC Limit	-Conc Added-		Percent Recovered	
		Unspiked Sample	MS/Sample	MSD/Dup			MS	MSD	MS	MSD
Alkalinity	09/10/92	0.00	23000.00	23000.00	0	20	23650.00	23650.00	97	97
Moisture	09/18/92		8.18	8.18	0	20				
pH	09/15/92		5.21	5.49	5	20				

* or N = Outside QC Limit:

QC Limits for % Rec: 75 - 125

ANALYST:

Don Pleator

Date

9/28/92

REVIEWER:

RWB

Date

9/29/92

File: M1QCMSWH

METALS DATA PACKAGE

INORGANIC ANALYSES DATA SHEET

V-7'3"

CLIENT SAMPLE ID

A-5

INORGANIC ANALYSES DATA SHEET

A-3

CLIENT SAMPLE ID

PBLANK

Concentration Units (ug/L or mg/kg dry weight): MG/KG

[illegible]

Comments:

EPA SAMPLE NO.

MPA-18L

Matrix (soil/water): SOIL_ Level (low/med): LOW_

[illegible]

Method Detection Limits (Annually)

Furnace AA ID Number : _____ (ug/L in 1.00g to 100ml digestate)

[illegible]

Comments:

ILMO2.1

Engineering Science - Berkeley Laboratory
Inorganics Report

ANALYSIS RUN LOG

Lab Name: E_S_BERKELEY_LABORATORY_

Contract: AFCEE_____

Code: ESBL_ Case No.: 4294S_

SAS No.: _____ SDG No.: A-3_

Instrument ID Number: TJA 61 M_

Method: P_

Start Date: 09/17/92

End Date: 09/17/92

EPA Sample No.	D/F	Time	% R	Analytes																									
				F	E																								
TD1	1.00	1423		X																									
TD2	1.00	1427		X																									
STD3	1.00	1432		X																									
STD4	1.00	1437		X																									
CV	1.00	1441		X																									
LCB	1.00	1446		X																									
ICSA	1.00	1451		X																									
CSAB	1.00	1455		X																									
RI	1.00	1500																											
PBLANK	1.00	1504		X																									
ZZZZZ	1.00	1509																											
CSS	1.00	1514		X																									
LCSSD	1.00	1518		X																									
A-8.5'	1.00	1523		X																									
-4.0'	1.00	1527		X																									
-18'	1.00	1532		X																									
CCV	1.00	1537		X																									
CB	1.00	1541		X																									
-7'3"	1.00	1546		X																									
A-5	1.00	1551		X																									
-3	1.00	1555		X																									
W-8	1.00	1600		X																									
MPA-07	1.00	1604		X																									
MPA-18	1.00	1609		X																									
PA-18S1	1.00	1614		X																									
PA-18S2	1.00	1618		X																									
MPA-18L	1.00	1623		X																									
CV	1.00	1627		X																									
CB	1.00	1632		X																									
MPB-18	1.00	1637		X																									
MPB-06	1.00	1641		X																									
PC-06	1.00	1646		X																									

ANALYSIS RUN LOG

Contract: AFCEE_____

SAS No. : _____ SDG No. : A-3_____

Method: P_

End Date: 09/17/92

ILMO2.1

**TOTAL KJELDAHL NITROGEN
TOTAL PHOSPHATE
SOIL CLASSIFICATION
DATA PACKAGE**



SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4310
Sample Descript: Soil
Analysis for: Total Kjeldahl Nitrogen
First Sample #: 209-0841

Sampled: ^{TP 9/23/92} ~~Aug~~ 1, 1992
Received: Sep 8, 1992
Analyzed: Sep 16, 1992
Reported: Sep 22, 1992

LABORATORY ANALYSIS FOR: Total Kjeldahl Nitrogen

Sample Number	Sample Description	Detection Limit mg/kg	Sample Result mg/kg
209-0841	R2-V-7-3"	20	37
209-0842	R2-A-5'-5.5'	20	31
209-0843	R2-A-3'-3.5'	20	70
-	Method Blank	20	N.D.

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL


Tod Granicher
Project Manager

Please Note:

Analysis results reported on a dry-weight basis.

2090841.ENG <5>



SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Sep. TP 9/23/92

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4310
Sample Descript: Soil
Analysis for: Total Phosphorous
First Sample #: 209-0841

Sampled: Aug 1, 1992
Received: Sep 8, 1992
Analyzed: Sep 16, 1992
Reported: Sep 22, 1992

LABORATORY ANALYSIS FOR: Total Phosphorous

Sample Number	Sample Description	Detection Limit mg/kg	Sample Result mg/kg
209-0841	R2-V-7'-3"	10	43
209-0842	R2-A-5'-5.5"	10	81
209-0843	R2-A-3'-3.5"	10	110
-	Method Blank	10	N.D.

**THIS REPORT HAS BEEN
APPROVED AND REVIEWED BY**

 10/14
ESBL PROJECT MANAGER DATE

Analytes reported as N.D. were not present above the stated limit of detection.

SEQUOIA ANALYTICAL


Tod Granicher
Project Manager

Please Note:

Analysis results reported on a dry-weight basis.

2090841.ENG <4>



SEQUOIA ANALYTICAL

680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4310

QC Sample Group: 209-0841-43

Revised: Sep 28, 1992

QUALITY CONTROL DATA REPORT

ANALYTE	Total Phosphorous	Total Kjeldahl Nitrogen

Method:	EPA365.3	EPA351.4
Analyst:	K. Follett	G. Kern
Reporting Units:	mg/kg	mg/kg
Date Analyzed:	Jul 16, 1992	Sep 16, 1992
QC Sample #:	209-0841	209-0843

Sample Conc.:	43	70
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Spike Conc. Added:	110	4300
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Conc. Matrix Spike:	130	3900
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Matrix Spike % Recovery:	79	89
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Conc. Matrix Spike Dup.:	140	4100
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Matrix Spike Duplicate % Recovery:	88	94
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Relative % Difference:	7.4	5.0
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Tod Granicher
Project Manager

% Recovery:	$\frac{\text{Conc. of M.S.} - \text{Conc. of Sample}}{\text{Spike Conc. Added}} \times 100$
Relative % Difference:	$\frac{\text{Conc. of M.S.} - \text{Conc. of M.S.D.}}{(\text{Conc. of M.S.} + \text{Conc. of M.S.D.}) / 2} \times 100$

2090841.ENG <6>



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(415) 364-9600 • FAX (415) 364-9233

Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4310
Sample Descript: Soil, R2-V-7-3"
Method of Analysis: ASTM. D422-63
Lab Number: 209-0841

Sampled: Aug 1, 1992
Received: Sep 8, 1992
Analyzed: Sep 15, 1992
Reported: Sep 22, 1992

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

- (A) TOTAL WEIGHT OF SAMPLE:
- (B) WEIGHT RETAINED IN NO. 10 SIEVE:
- (C) % PASSING NO. 10 SIEVE:

211.94g
2.99g
98.59%

SIEVE TEST FOR
WEIGHT RETAINED
IN NO. 10 SIEVE

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½in.	0.0	0.0	0.0	100
3/8in.	0.0	0.0	0.0	100
No. 4	0.35	0.17	0.17	99.83
No. 10	2.64	1.25	1.42	98.58
PAN	0.0			
TOTAL	2.99			

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	21	21	17	13.5	0.035	26
5	21	20	16	13.7	0.022	24
10	21	19	15	13.8	0.016	23
15	21	18	14	14.0	0.013	21
25	21	18	14	14.0	0.010	21
40	21	17	13	14.2	0.0080	20
60	21	17	13	14.2	0.0066	20
90	21	16	12	14.3	0.0054	18
120	21	15	11	14.5	0.0047	17
1440	21	12	8	15.0	0.0014	12

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):
 HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):
 SPECIFIC GRAVITY (ASSUMED):
 DISPERSING AGENT CORRECTION FACTOR (E):
 MENISCUS CORRECTION FACTOR (F):
 TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):

65g
0.994
2.65
3
1
0.01348

FORMULAS:
 $R = H - E - F$
 $S = K [\text{SQRT} (L / T)]$
 $P = (R / W) 100$
 $W = (J \cdot 100) / C$
 $J = D \cdot G$

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Tod Granicher
Project Manager



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Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4310
Sample Descript: Soil, R2-A-5'-5.5'
Method of Analysis: ASTM D422-63
Lab Number: 209-0842

Sampled: Aug 1, 1992
Received: Sep 8, 1992
Analyzed: Sep 15, 1992
Reported: Sep 22, 1992

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

- (A) TOTAL WEIGHT OF SAMPLE:
- (B) WEIGHT RETAINED IN NO. 10 SIEVE:
- (C) % PASSING NO. 10 SIEVE:

222.32g
4.03g
98.19%

SIEVE TEST FOR
WEIGHT RETAINED
IN NO. 10 SIEVE

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1½in.	0.0	0.0	0.0	100
3/8in.	0.0	0.0	0.0	100
No. 4	0.18	0.08	0.08	99.92
No. 10	3.85	1.73	1.81	98.19
PAN	0.0			
TOTAL	4.03			

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	20	28	24	12.4	0.034	37
5	20	27	23	12.5	0.022	35
10	20	26	22	12.7	0.015	34
15	20	25	21	12.9	0.013	32
25	20	25	21	12.9	0.010	32
40	20	24	20	13.0	0.0078	30
60	20	24	20	13.0	0.0064	30
90	20	24	20	13.0	0.0052	30
120	20	23	19	13.2	0.0045	29
1440	20	20	16	13.7	0.0013	24

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):
 HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):
 SPECIFIC GRAVITY (ASSUMED):
 DISPERSING AGENT CORRECTION FACTOR (E):
 MENISCUS CORRECTION FACTOR (F):
 TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):

65g
0.992
2.65
3
1
0.01365

FORMULAS:

$$R = H - E - F$$

$$S = K [\text{SQRT} (L / T)]$$

$$P = (R / W) 100$$

$$W = (J \cdot 100) / C$$

$$J = D \cdot G$$

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 Tod Granicher
 Project Manager



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Engineering Science, Inc.
600 Bancroft Way
Berkeley, CA 94710
Attention: Tom Paulson

Client Project ID: W.O. #4310
Sample Descript: Soil, R2-A-3'-3.5'
Method of Analysis: ASTM D422-63
Lab Number: 209-0843

Sampled: Aug 1, 1992
Received: Sep 8, 1992
Analyzed: Sep 15, 1992
Reported: Sep 21, 1992

PARTICLE SIZE DISTRIBUTION BY SIEVE AND HYDROMETER

SIEVE TEST

- (A) TOTAL WEIGHT OF SAMPLE:
- (B) WEIGHT RETAINED IN NO. 10 SIEVE:
- (C) % PASSING NO. 10 SIEVE:

205.99g
19.88g
90.35%

SIEVE TEST FOR
WEIGHT RETAINED
IN NO. 10 SIEVE

IDEAL PAN = 0.0
IDEAL TOTAL = (B)

SIEVE SIZE	WEIGHT RETAINED, g	% RETAINED	CUMULATIVE % RETAINED	CUMULATIVE % PASSING
1 1/2 in.	0.0	0.0	0.0	100
3/8 in.	2.80	1.36	1.36	98.64
No. 4	4.91	2.38	3.74	96.26
No. 10	12.17	5.91	9.65	90.35
PAN	0.0			
TOTAL	19.88			

HYDROMETER TEST

ELAPSED TIME (T)	TEMP. °C	HYDROMETER READING (H)	CORRECTED READING (R)	(L)	PARTICLE DIAM. (S)	% SUSPENDED (P)
2	20	24	20	13.0	0.035	28
5	20	23	19	13.2	0.022	27
10	20	22	18	13.3	0.016	25
15	20	22	18	13.3	0.013	25
25	20	22	18	13.3	0.010	25
40	20	21	17	13.5	0.0079	24
60	20	20	16	13.7	0.0065	22
90	20	20	16	13.7	0.0053	22
120	20	19	15	13.8	0.0046	21
1440	20	18	14	14.0	0.0013	20

WEIGHT OF SOIL USED IN HYDROMETER TEST (D):
 HYGROSCOPIC MOISTURE CORRECTION FACTOR (G):
 SPECIFIC GRAVITY (ASSUMED):
 DISPERSING AGENT CORRECTION FACTOR (E):
 MENISCUS CORRECTION FACTOR (F):
 TEMP./SPEC. GRAVITY DEPENDANT CONSTANT (K):

65g
0.990
2.65
3
1
0.01365

FORMULAS:
 $R = H - E - F$
 $S = K [\text{SQRT} (L / T)]$
 $P = (R / W) 100$
 $W = (J \cdot 100) / C$
 $J = D \cdot G$

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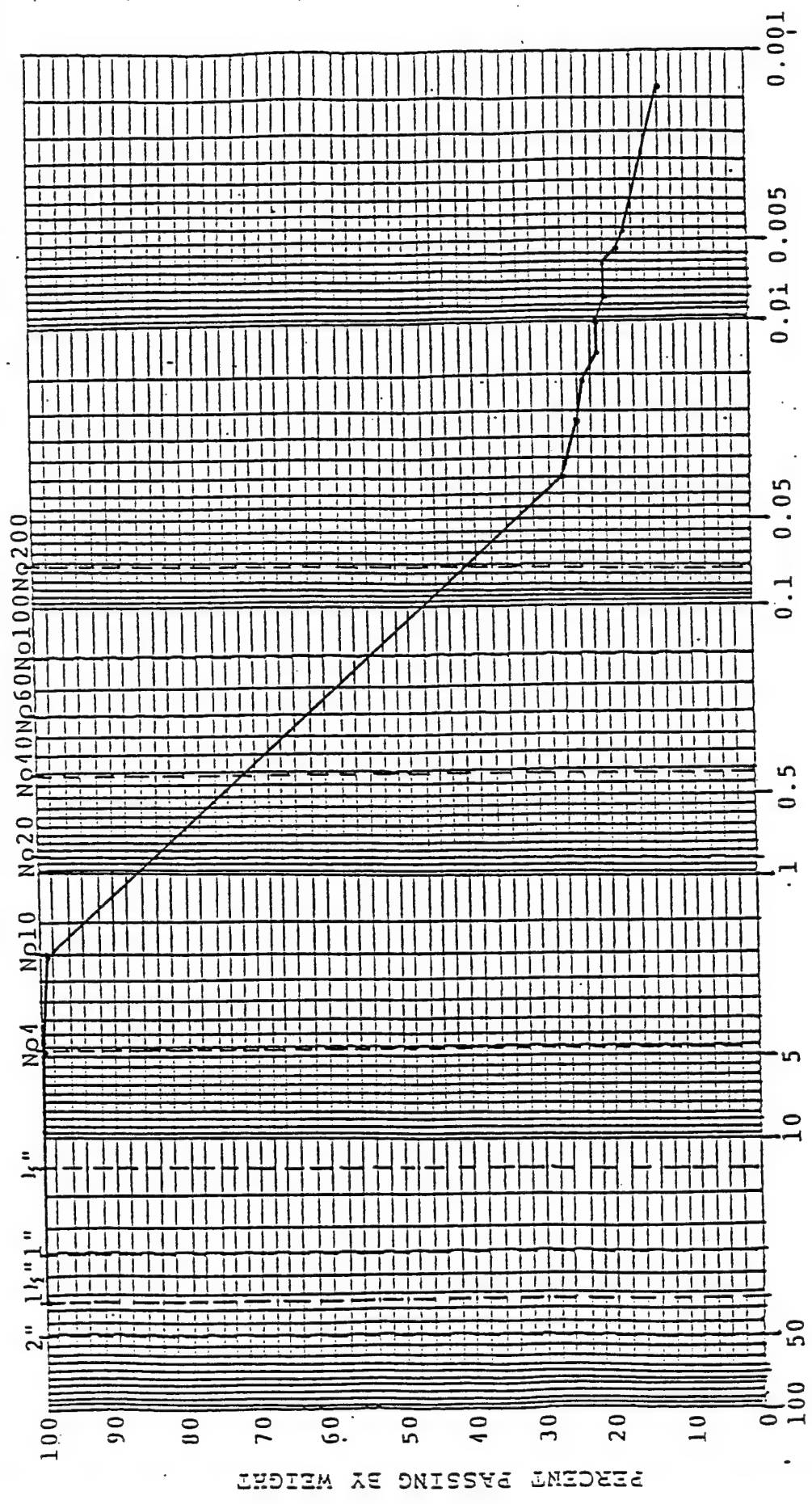

 Tod Granicher
 Project Manager

SAMPLE DESCRIPTION: Engineering Science, Inc.

LABORATORY NUMBER: 209-0841

U.S. STANDARD SIEVE SIZES

SAND	61%
SILT	25%
CLAY	14%



GRAIN DIAMETER IN MILLIMETERS

COBBLES		SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE	SILT SIZES	CLAY SIZES

268

CLAY

U.S. STANDARD SIEVE SIZES

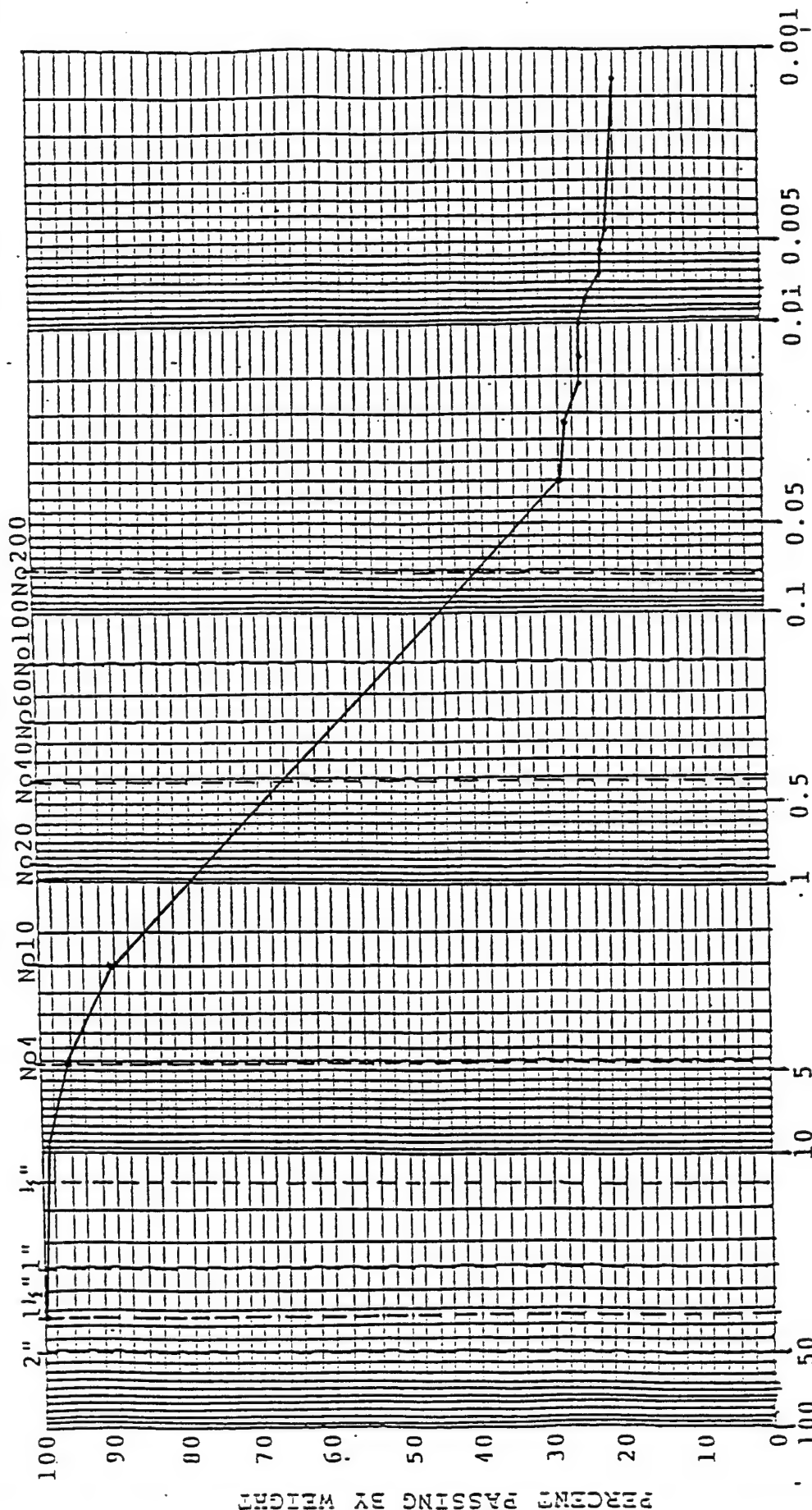


	GRAIN DIAMETER						
	COARSE	FINE	COARSE	MEDIUM	FINE		
	GRAVEL		SAND			FINES	
						SILT SIZES	CLAY SIZES
COBBLES							

SAMPLE DESCRIPTION: Engineering Science, Inc.

LABORATORY NUMBER: 209-0843

U.S. STANDARD SIEVE SIZES



SAND	57%
SILT	19%
CLAY	20%

GRAIN DIAMETER IN MILLIMETERS

COBBLES			SAND			FINES	
COARSE	FINE	COARSE	MEDIUM	FINE		SILT SIZES	CLAY SIZES

CHAIN OF CUSTODY RECORD

[illegible]

APPENDIX C
SITE UST 173 SOIL GAS PERMEABILITY DATA

Table C-1. Results of Soil Gas Permeability Test at Monitoring Point R1-MPA

Time (min)	Pressure ("H ₂ O) by Depth			Time (min)	Pressure ("H ₂ O) by Depth		
	6.8'	14.25'	21.8'		6.8'	14.25'	21.8'
0	0	0.01	0.01	20	0	0.22	0.25
1	0	0.14	0.23	23	0	0.215	0.25
2	0	0.145	0.235	26	0	0.22	0.25
3	0	0.155	0.235	29	0	0.215	0.25
4	0	0.165	0.235	32	0	0.22	0.25
5	0.005	0.170	0.24	37	0	0.22	0.25
6	0.005	0.180	0.24	42	0	0.205	0.25
7	0.005	0.185	0.24	47	0	0.235	0.25
8	0	0.19	0.239	57	0	0.235	0.25
9	0	0.185	0.245	67	0	0.25	0.30
10	0	0.185	0.245	77	0	0.25	0.35
12	0	0.190	0.25	87	0	0.25	0.35
14	0	0.190	0.25	107	0	0.25	0.35
16	0	0.195	0.25	127	0	0.25	0.35
18	0	0.20	0.25	147	0	0.25	0.35

Table C-2. Results of Soil Gas Permeability Test at Monitoring Point R1-MPB

Time (min)	Pressure ("H ₂ O) by Depth			Time (min)	Pressure ("H ₂ O) by Depth		
	8.0'	15.0'	23.0'		8.0'	15.0'	23.0'
0	<0	<0	0.02	23	0.01	0.19	0.20
1	0.005	0.1	0.12	26	0.01	0.19	0.20
2	0.01	0.12	0.135	29	0.01	0.185	0.19
3	0.015	0.13	0.14	32	0.005	0.175	0.19
4	0.025	0.13	0.145	38	0.005	0.18	0.195
5	0.02	0.135	0.155	48	0.03	0.195	0.21
6	0.025	0.14	0.155	53	0.025	0.20	0.22
7	0.025	0.14	0.155	58	0.02	0.2	0.22
8	0.025	0.145	0.16	68	0.03	0.21	0.235
9	0.25	0.14	0.16	78	0.14	0.25	0.30
10	0.025	0.14	0.16	88	0.10	0.25	0.30
12	0.02	0.16	0.17	98	0.04	0.25	0.27
14	0.015	0.16	0.175	108	<0	0.24	0.25
16	0.01	0.165	0.185	118	<0	0.22	0.30
18	0.015	0.17	0.19	138	<0	0.22	0.30
20	0.01	0.18	0.20	148	<0	0.21	0.30

Table C-3. Results of Soil Gas Permeability Test at Monitoring Point R1-MPC

Time (min)	Pressure ("H ₂ O) by Depth			Time (min)	Pressure ("H ₂ O) by Depth		
	8.0'	15.0'	23.0'		8.0'	15.0'	23.0'
0	0	0.02	0.02	26	0.013	0.165	0.165
1	0	0.095	0.10	29	0.015	0.165	0.165
2	0	0.11	0.11	32	0.013	0.173	0.170
3	0.005	0.115	0.119	35	0.013	0.173	0.175
4	0.007	0.12	0.12	40	0.013	0.167	0.163
5	0.01	0.135	0.135	45	0.015	0.185	0.185
6	0.01	0.145	0.145	50	0.015	0.193	0.193
7	0.01	0.137	0.140	55	0.010	0.193	0.193
8	0.01	0.139	0.140	60	0.017	0.203	0.196
9	0.01	0.140	0.140	70	0.020	0.200	0.196
10	0.01	0.147	0.150	80	0.020	0.220	0.220
12	0.01	0.155	0.155	90	0.020	0.227	0.227
14	0.01	0.155	0.157	100	0.017	0.225	0.222
16	0.013	0.163	0.165	110	0.015	0.222	0.222
18	0.013	0.165	0.167	120	0.025	0.245	0.243
20	0.015	0.180	0.183	140	0.02	0.220	0.220
23	0.013	0.183	0.183				

APPENDIX D

SITE UST 173 IN SITU RESPIRATION TEST DATA

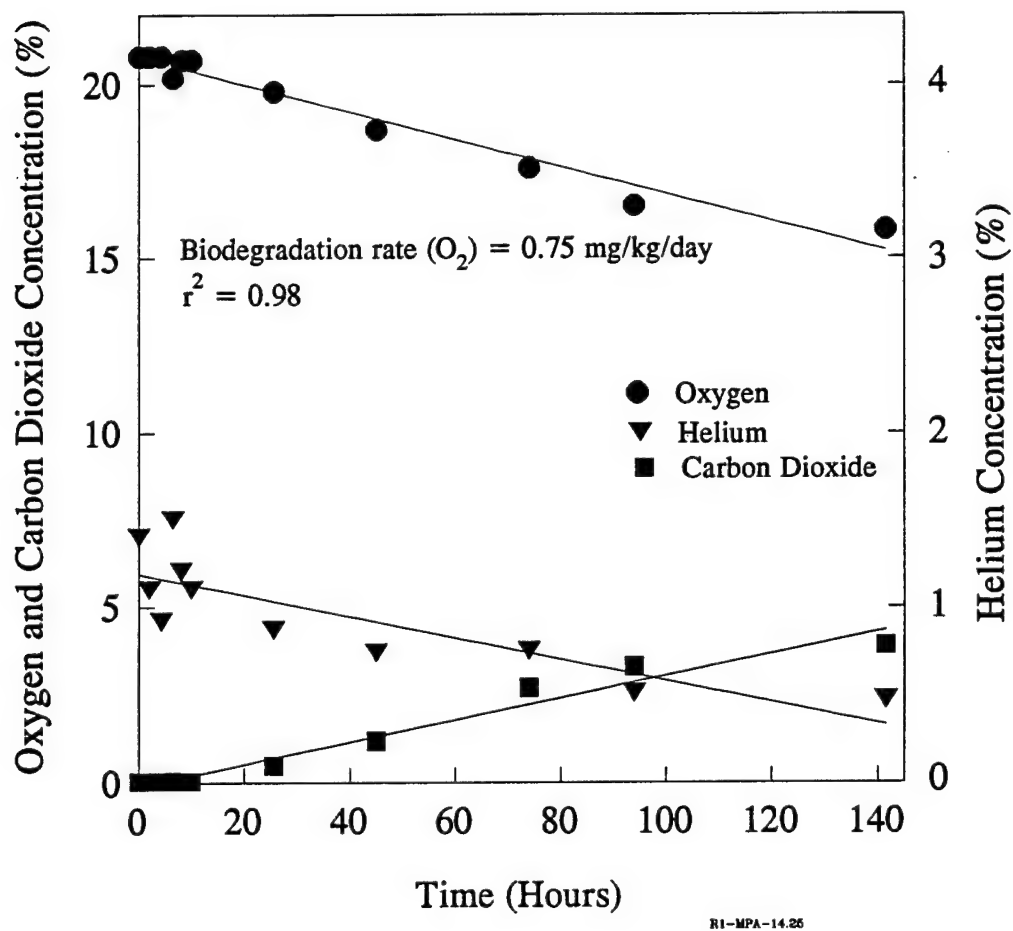


Figure D-1. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point R1-MPA-14.25'

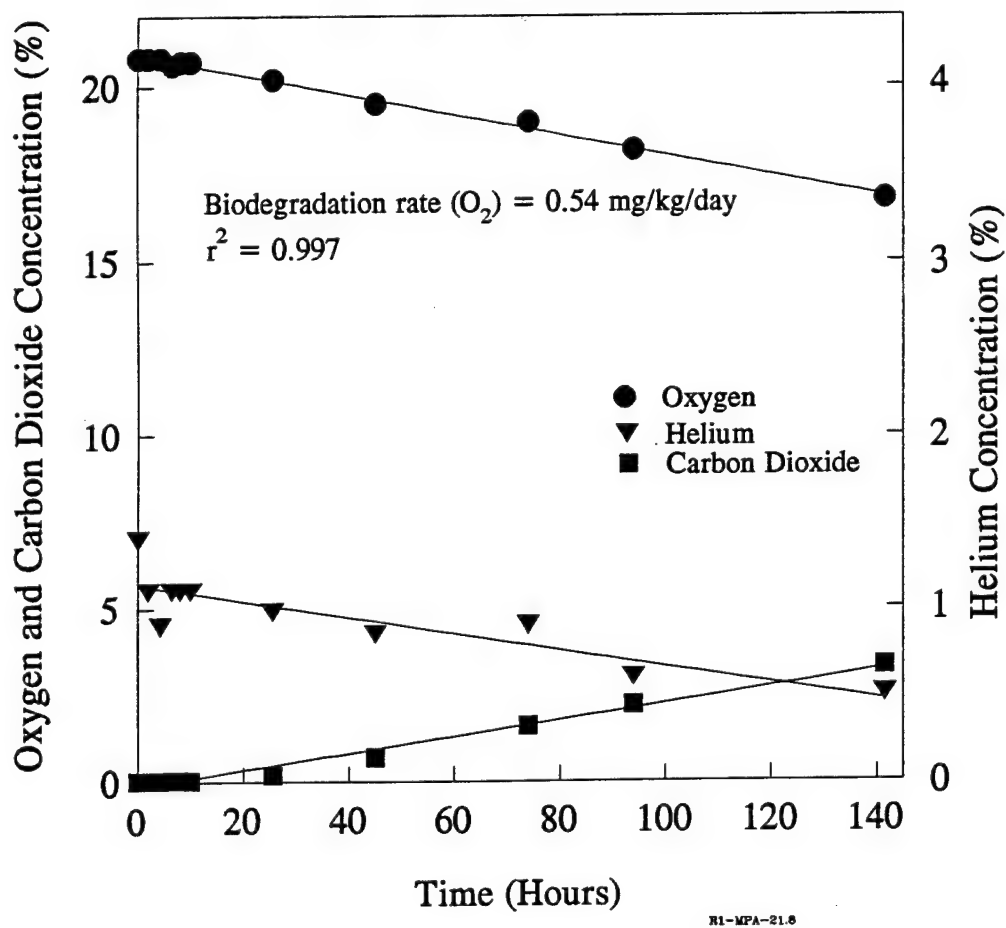


Figure D-2. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point R1-MPA-21.8'

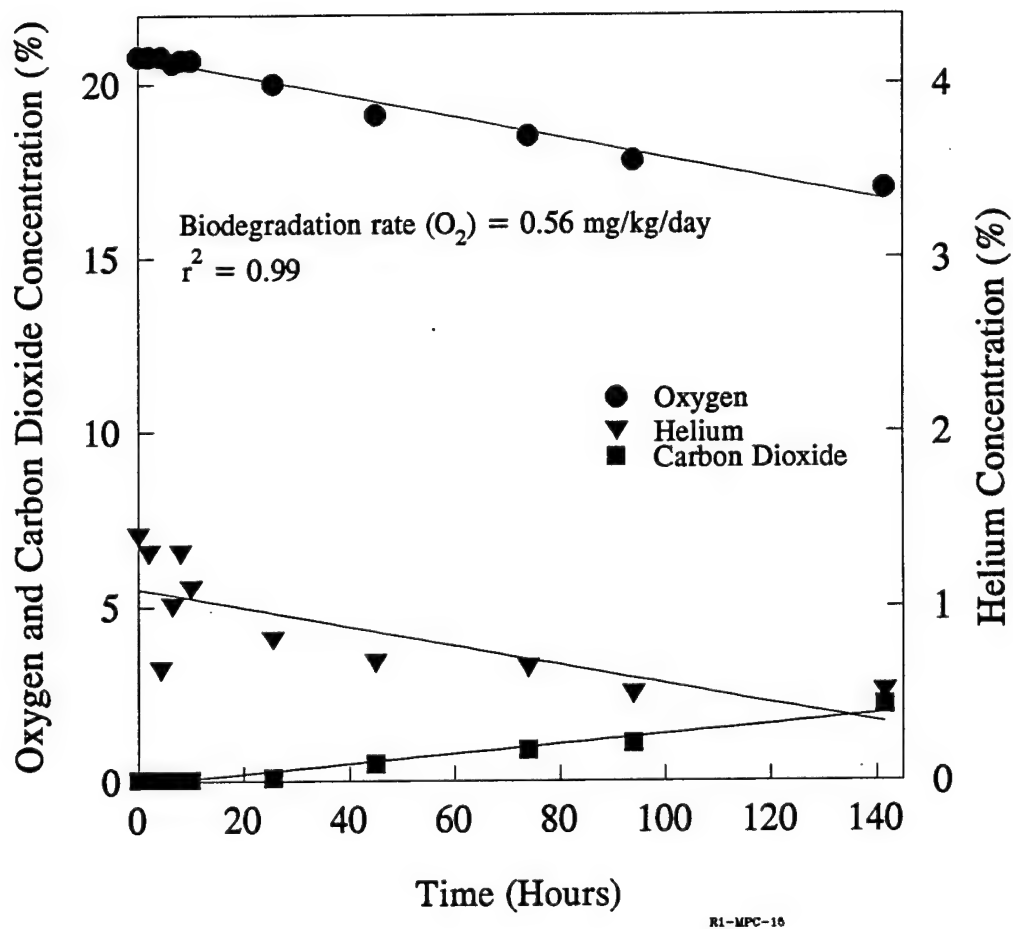


Figure D-3. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point R1-MPC-15.0'

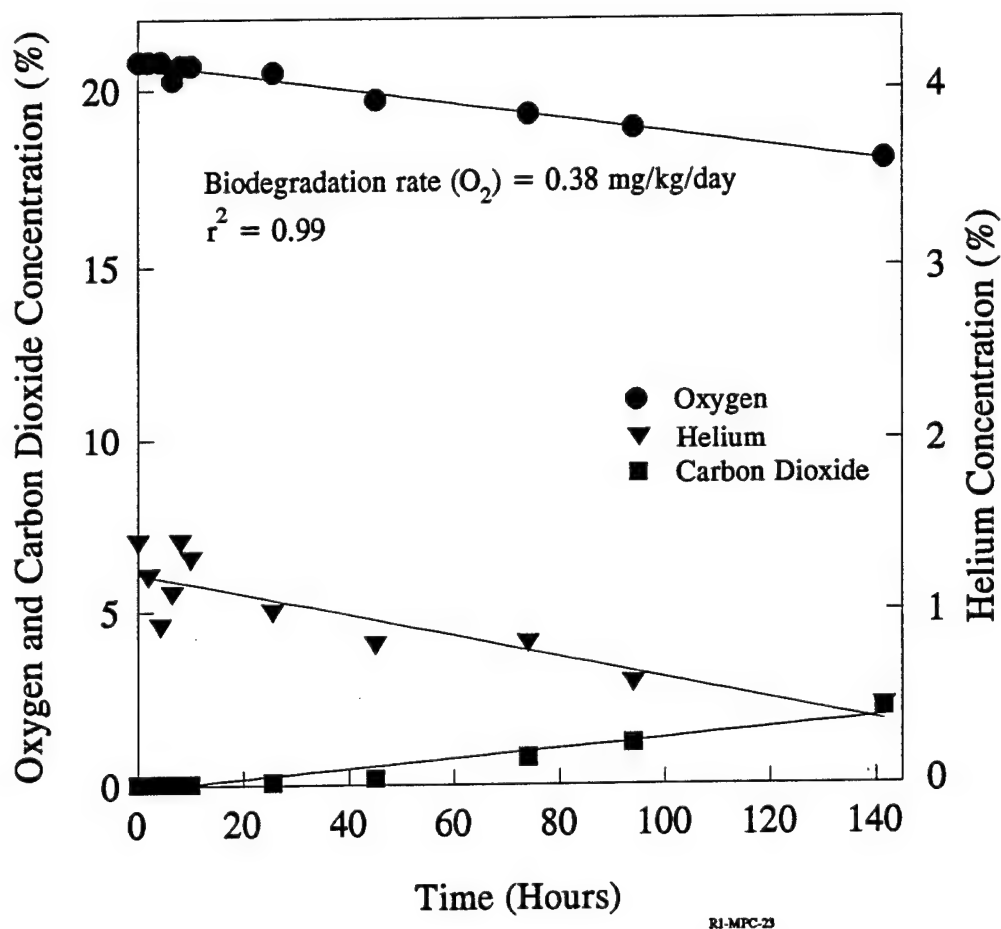


Figure D-4. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point R1-MPC-23.0'

APPENDIX E

SITE SS-10 SOIL GAS PERMEABILITY DATA

Table E-1. Results of Soil Gas Permeability Test at Monitoring Point R2-MPA

Time (min)	Pressure ("H ₂ O) by Depth			Time (min)	Pressure ("H ₂ O) by Depth		
	6.0'	4.5'	3.0'		6.0'	4.5'	3.0'
0	0.005	0.005	0	18	18.0	17.9	0.015
1	17.5	17	0.015	21	18.1	18.0	0.015
2	17.6	17.5	0.015	24	18.0	17.9	0.015
3	17.7	17.8	0.015	27	18.1	17.9	0.015
4	18	17.9	0.015	30	18.2	17.9	0.015
5	18.5	17.9	0.015	35	18.2	17.9	0.015
6	18.5	17.5	0.015	40	18.2	17.9	0.015
7	18.5	17.5	0.015	45	18.2	18.0	0.015
8	18.0	17.5	0.15	55	18.2	18.1	0.015
9	17.9	17.6	0.010	65	18.3	18.0	0.015
10	17.9	17.6	0.010	75	18.5	18.0	0.015
11	17.9	17.5	0.010	95	18.5	18.0	0.015
12	17.9	17.5	0.010	115	18.5	18.0	0.015
15	17.9	17.5	0.010	135	18.5	18.0	0.015

Table E-2. Results of Soil Gas Permeability Test at Monitoring Point R2-MPB

Time (min)	Pressure ("H ₂ O) by Depth			Time (min)	Pressure ("H ₂ O) by Depth		
	3.0'	4.5'	9.0'		3.0'	4.5'	9.0'
0	0	0.015	0.02	15	0.05	6.0	6.5
1	0.02	3.7	4.5	17	0.054	6.0	6.5
2	—	—	—	20	0.054	6.0	6.5
3	0.042	5.6	6.2	25	0.066	6.4	6.6
4	—	—	—	30	0.055	6.3	6.7
5	0.047	6.0	6.4	40	0.055	6.4	6.9
6	—	—	—	50	0.06	6.5	7.0
7	0.052	6.0	6.4	60	0.057	6.6	7.2
8	—	—	—	80	0.049	6.7	7.4
9	0.050	5.9	6.3	100	0.047	6.8	7.5
10	—	—	—	120	0.044	7.0	7.6
11	0.05	5.9	6.3	140	0.047	7.0	7.7
13	0.05	6.0	6.4				

Table E-3. Results of Soil Gas Permeability Test at Monitoring Point R2-MPC

Time (min)	Pressure ("H ₂ O) by Depth			Time (min)	Pressure ("H ₂ O) by Depth		
	3.0'	4.5'	6.0'		3.0'	4.5'	6.0'
0	0	0	0	13	0	0.225	0.22
1	<0	0.02	0.04	15	0	0.27	0.245
2	—	—	—	17	0	0.29	0.270
3	0	0.03	0.06	20	0	0.37	0.32
4	—	—	—	25	0	0.23	0.27
5	0	0.1	0.125	30	0	0.27	0.23
6	—	—	—	40	0	0.22	0.205
7	0	0.065	0.085	50	0	0.27	0.25
8	—	—	—	60	0	0.23	0.22
9	0.02	0.045	0.07	80	0	0.23	0.222
10	—	—	—	100	0	0.235	0.215
11	0	0.205	0.19				

APPENDIX F

SITE SS-10 IN SITU RESPIRATION TEST DATA

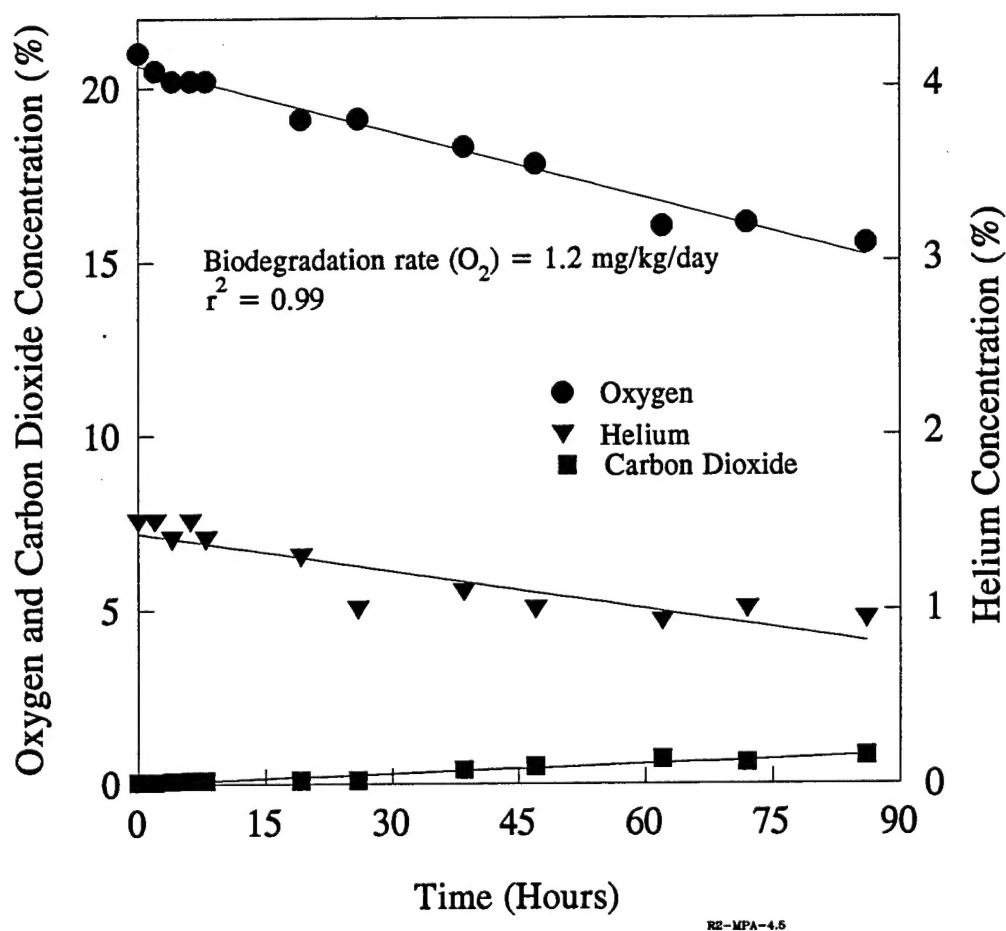


Figure F-1. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point R2-MPA-4.5'

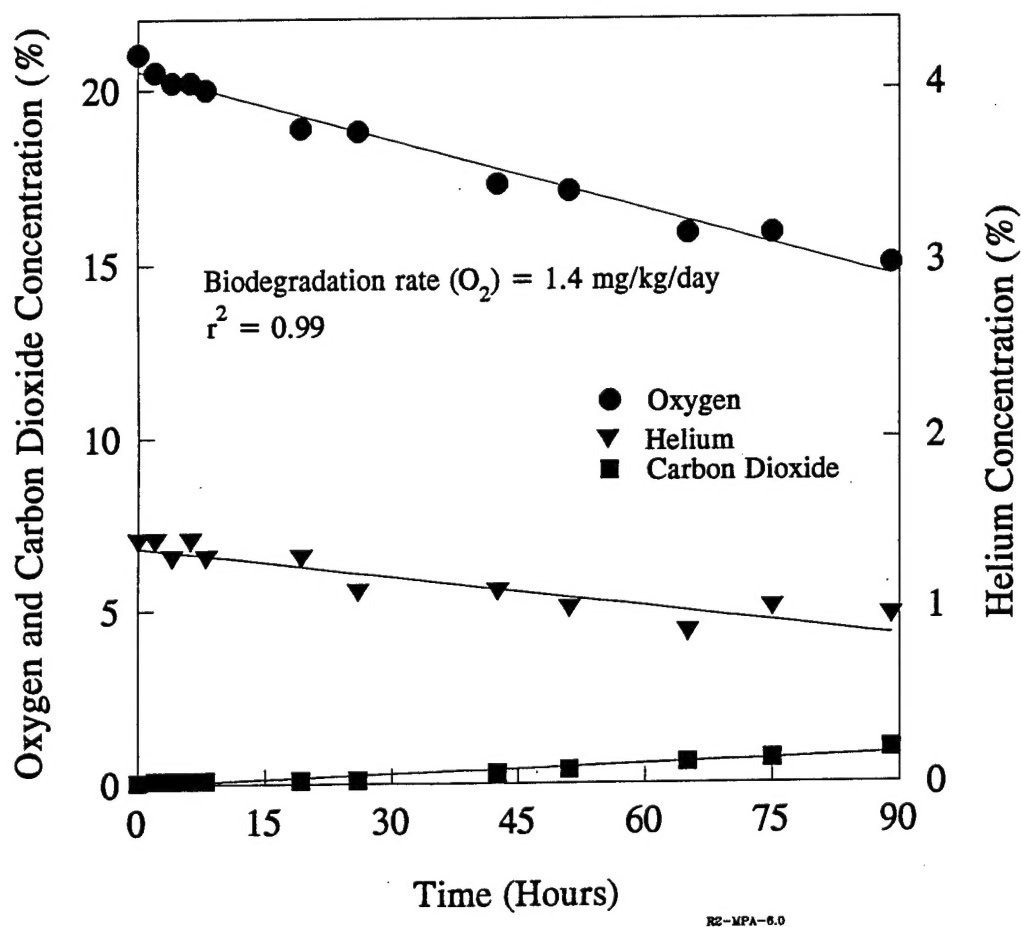


Figure F-2. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point R2-MPA-6.0'

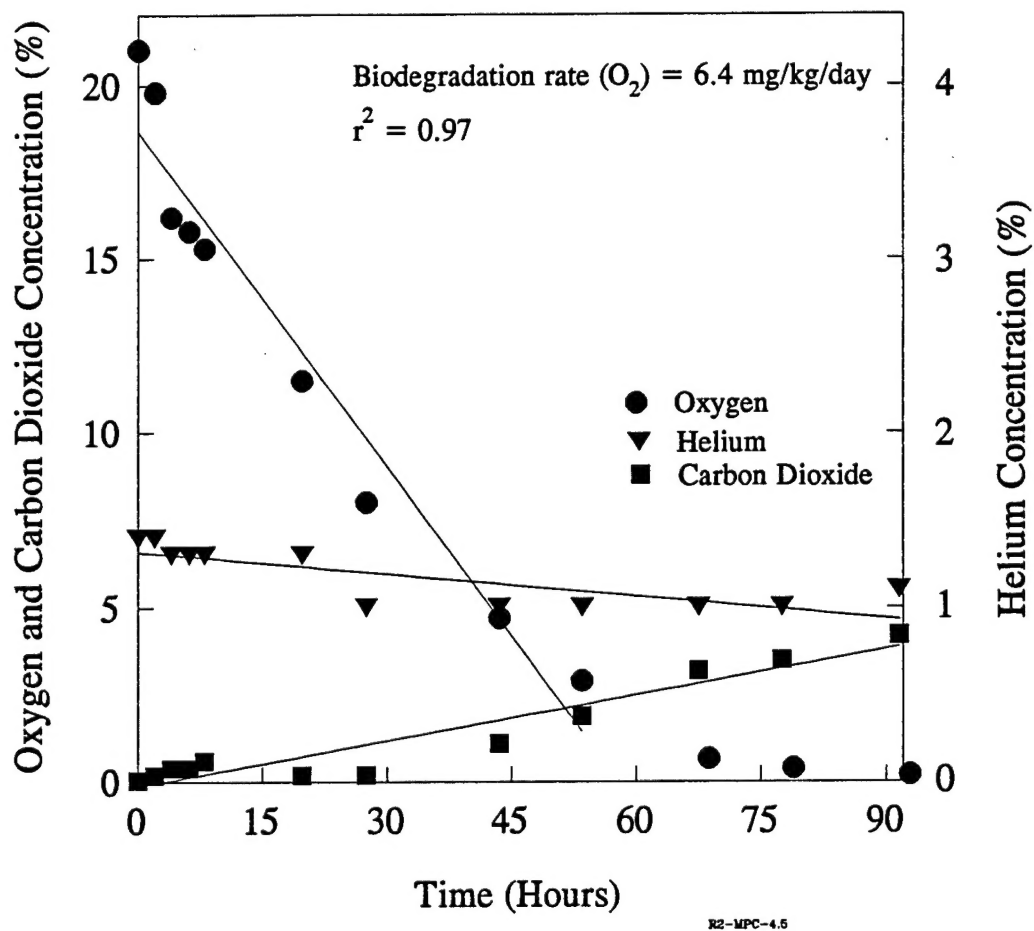


Figure F-3. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point R2-MPC-4.5'

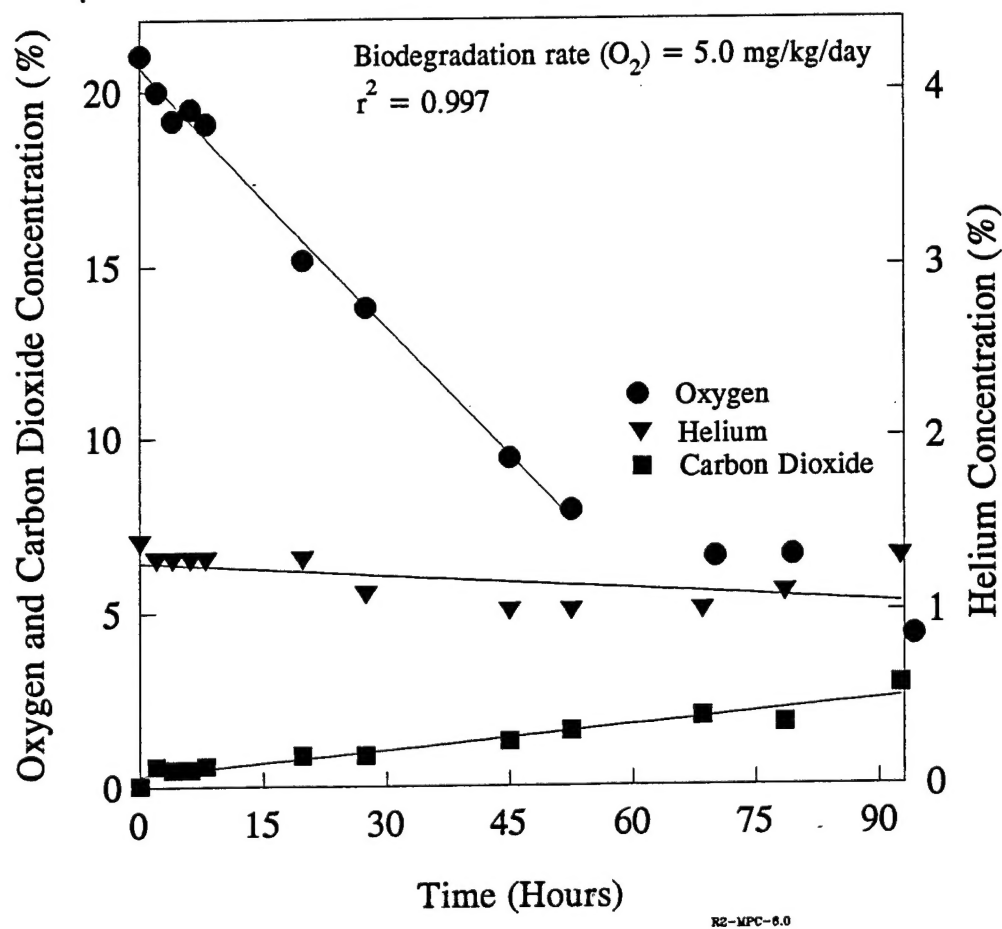


Figure F-4. Oxygen Utilization and Carbon Dioxide Production During the In Situ Respiration Test at Monitoring Point R2-MPC-6.0'